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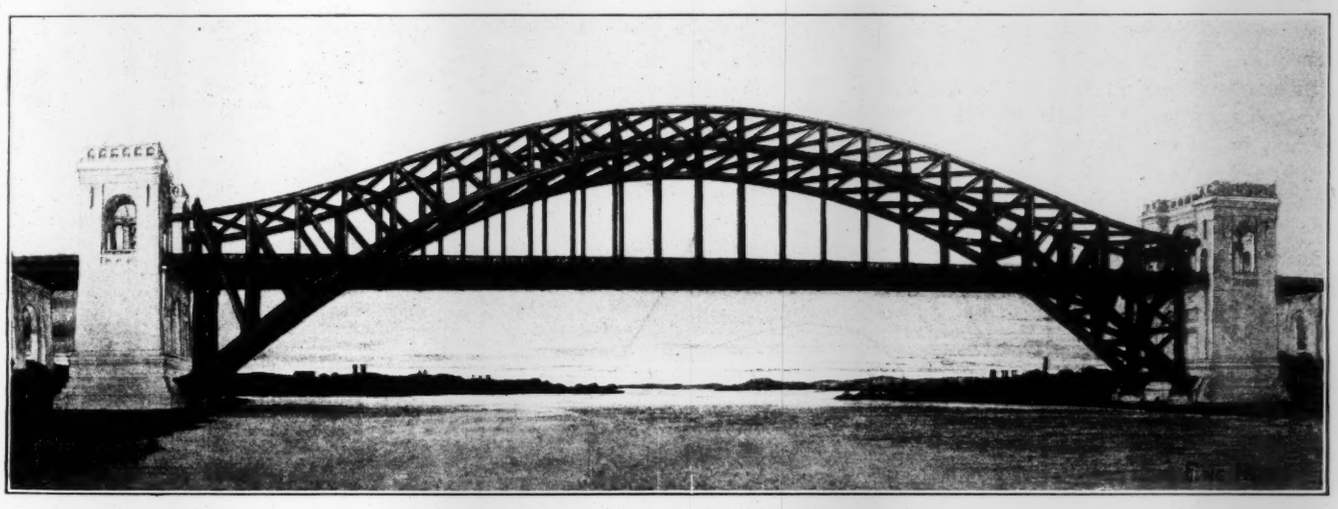
The Hell Gate Steel Arch Bridge

The Hell Gate steel arch bridge, the world's largest arch, is now actively under construction. The Long Island abutment pier is well under way and the foundation for the Wards Island pier is nearly complete. The steelwork is being fabricated in the shops of the American Bridge Co., practically all detail drawings having been made. Fabricated steelwork is already being shipped to Greenville and erection of the arch will probably begin next year.

In our issue of May 30, 1907, p. 583, we showed a picture of the Hell Gate arch as then designed. The bridge as now being built is the same with minor architectural changes in the terminal towers.



THE LONGEST STEEL ARCH BRIDGE IN THE WORLD

Marked originality of design characterizes the structure. The outline of the arch is in itself strikingly original. Other innovations are:

Hard (high-carbon) steel; large rivets; heavy splicing; special pivot or rocker joints at chord splices; braking girders in the floor; cantilever arrangement of the floor laterals.

The bridge is also notable for the magnitude of its chord sections and their robust makeup; for the great weight of single members—weighing twice as much as the heaviest erection parts of large bridges previously erected; and for its great weight, which averages about 38,000 lb. steel and 53,000 lb. total per lineal foot of bridge. The great weight is due to the large live-load capacity provided. No existing large-span bridge is designed for four lines of railway traffic.

GENERAL ARRANGEMENT

The Hell Gate arch, shown by view in Fig. 1 and by general drawings in Fig. 2, is a two-hinged framed arch of 1017-ft. span between towers, 977½-ft. span c. to c. of hinges and 220-ft. rise from hinges to crown of lower chord. The arch depth at crown is 40 ft. The clearance line is 135 ft. above mean high water, and the arch rises about 150 ft. above the roadway. While two-hinged in final condition, the arch will be erected as a three-hinged structure and the top chords connected only after all dead-load is in place.

The lower chord is of parabolic outline, and intersects the floor three panels out from the abutments. The curvature of the upper chord is flatter than that of the lower chord and near the end becomes concave upward, this chord remaining above the roadway throughout. The arches are in vertical planes, 60 ft. apart c. to c.; the roadway wind-truss, however, is wider, its chords being 93 ft. apart. The floor outside of the trusses is designed for light loading, being utilized only as an inspection footway.

The paneling of the arch is simple, and the panel-length relatively small—42½ ft. (23 panels). The web posts are vertical. The chords change direction at every panel-point.

BRACING

The bracing of arch and floor is arranged in an effective manner, worth careful study. Both upper and lower chords have a complete lateral system of double-triangle webbing. These systems come together in the bottom chord at the point where this chord intersects the roadway; just above here the lower chord bracing has an inclined portal and the upper chord bracing a vertical portal, developed in place of the regular sway frame. The arch bracing passes thence down the lower chord to the shoes, each of the two web systems delivering its stress to one of the shoes. There is a light strut between the shoes, but it is not intended for carrying wind stress.

The main roadway bracing is a cantilever system, sup-

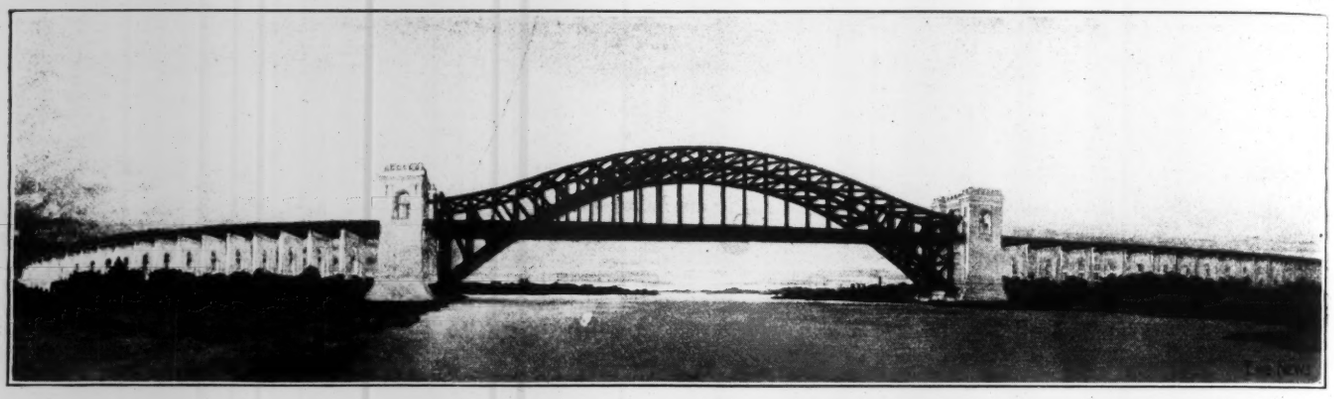


FIG 1. VIEW OF HELL GATE ARCH BRIDGE AND SECTIONS OF VIADUCT

ported at the point where the lower chord of the arch intersects the roadway, and anchored by vertical bracing between the end posts of the arch over the abutment. The support is furnished by the lower chord bracing, and thus the roadway wind load also passes down the bracing of the lower chord from the roadway to the abutment. The joint in the cantilever is formed three panels out from the intersection of lower chord and roadway by bringing the roadway laterals to the middle point of the floorbeam, the chords of the wind truss being cut in this panel. At this point, also, the stringers have an expansion joint (at one end of the bridge only).

Sway frames are fitted at all panel-points. In the middle portion of the arch the diagonals are adjustable rods and serve for erection purposes only. Where the bottom chord of the arch is below the floor, the riveted sway frames extend from the floorbeam down to the bottom chord. In the middle portion of the arch they occupy the depth between chords, but here, on account of the web system of the laterals, there are no transverse struts to complete the sway frames. In the plane of the end posts there is a very heavy portal above the floor and a sway frame below the floor to furnish anchorage for the end of the roadway wind truss.

BRAKING GIRDER

The intersection of bottom chord and floor is also the point at which longitudinal forces (from drag of braked trains) are transferred from the floor to the arch. This is done by a horizontal plate-girder in the plane of the floor, which takes the push of the stringers and converts it into a horizontal load on the arches. At one end of the bridge, this girder has to take the drag on only six stringer panels (from the end of the arch to the expansion joint of the stringers). At the opposite end, however, there is no expansion joint in the stringers, and the braking girder takes care of 17 panels.

SECTION AND MAKEUP OF THE MEMBERS

The arch has practically no tension in its chords; the bottom chord has no tension under any conditions, on account of the large dead-load. Therefore, the only tension splices occurring are in web members, which are of relatively small section, and there are no large tension splices in the structure. However, all splices, whether tension or compression, are 100% splices, except those in the bottom chord, where splices of 70 to 80% capacity are made.

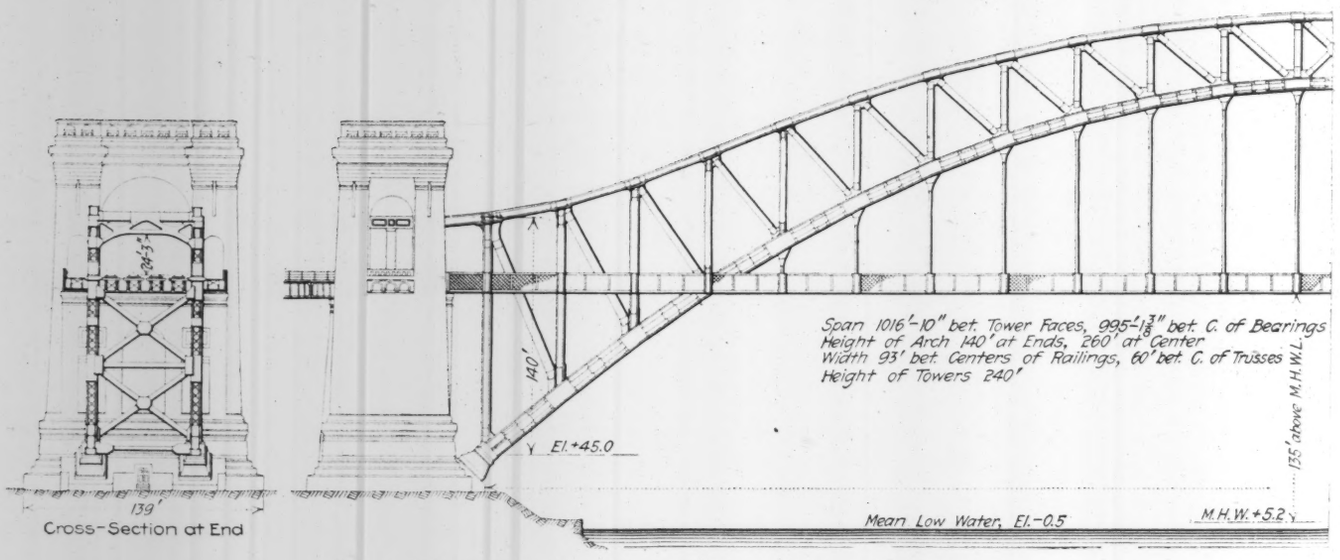

24'-3"
139'
Cross-Section at End
140'
El.+45.0
Span 1016'-10" bet. Tower Faces, 995'-1⅞" bet. C. of Bearings
Height of Arch 140' at Ends, 260' at Center
Width 93' bet. Centers of Railings, 60' bet. C. of Trusses
Height of Towers 240'
135' above M.H.W.L.
Mean Low Water, El.-0.5
M.H.W.+5.2

FIG. 2. GENERAL DRAWING OF HELL GATE ARCH BRIDGE

Fig. 3 sketches three typical members in cross-section. The section of the lower chord is the matter of first interest. It is rectangular, about 7 ft. wide and varying in depth from 7½ ft. at the crown to 10½ ft. at the abutment. The maximum cross-section required was about 1385 sq.in., and this is provided as sketched

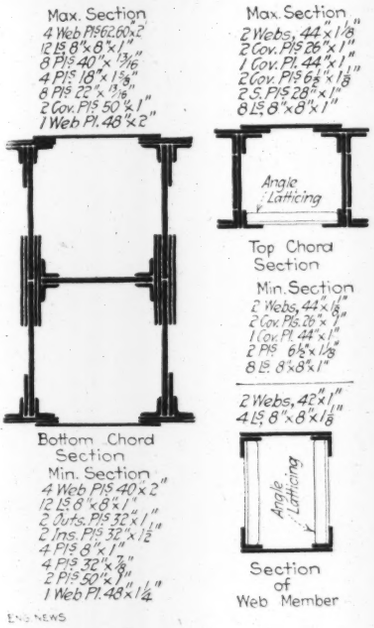


FIG. 3. TYPICAL SECTIONS OF MEMBERS, HELL GATE ARCH

by a box section with middle horizontal diaphragm. The depth and thickness of the web-plates are so great that each web is made in two widths, spliced on the horizontal center line, the splice plates, of course, adding to the effective section.

The top chord is of inverted U-shape, with side plates and top plate, the bottom being latticed. The sections here, while large, are not remarkable in the same sense as those of the bottom chord. The same may be said of the web members, which are in all cases two-rib members made up of two built-up channels latticed top and bottom.

Of the other members of the bridge, the floorbeams are of notable dimensions. They span some 60 ft. and carry eight lines of 42½-ft. stringers. They are of box-girder section, 9½ ft. deep and 3½ ft. wide over the coverplates with open bottom.

The general treatment of the connections of members is illustrated by Fig. 4, one of the heaviest panel-points (and splices) of the lower chord. The web stresses in an arch being relatively small, the connections are far simpler than in a truss, but as the drawing shows they attain respectable dimensions.

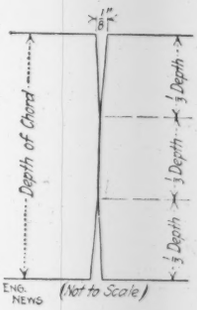


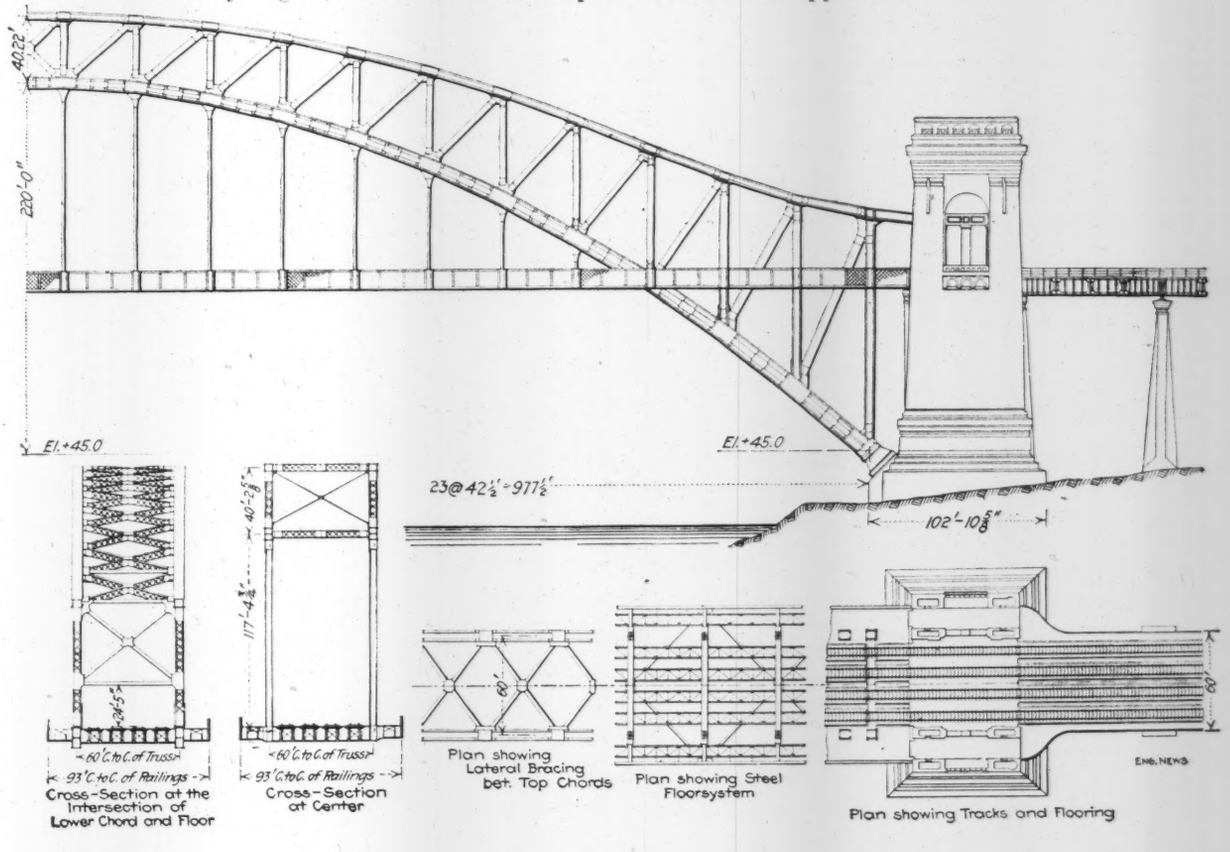
FIG. 5. JOINT PLANING OF CHORDS

JOINTS AND HINGES

An important original feature has been introduced in the splices. The joints of the compression members are so made as to approximate hinge joints until final riveting up. The sketch Fig. 5 illustrates the arrangement. The middle third of the width of the joint is planed to the true joint plane, while the outer thirds are backed off on a very slight taper, such that when two adjoining members are butted in true position the joint is open one-eighth inch on each side. The original idea was to plane the joint faces to arcs of circles corresponding to the three-segment form shown and used. But this was altered to the three-segment form on account of the difficulty of producing the curved form. The joint within the splice shown in Fig. 4 is of this "hinge" type, but of course the appearance of splice or connections is in no way affected by the special character of the joint.

The bottom chord has at each end a cast-steel shoe whose lower face is planed to a radius of 1150 in. and rests on the cast-steel bearing whose top face is planed to a perfect plane. The hinge thus formed is strongly doweled by separate dowel pieces set in pockets in the joint, in order to provide against any non-axial thrust.

The cast-steel shoes and bearings are each made in several sections. A riveted-steel hood will cover them for better appearance.



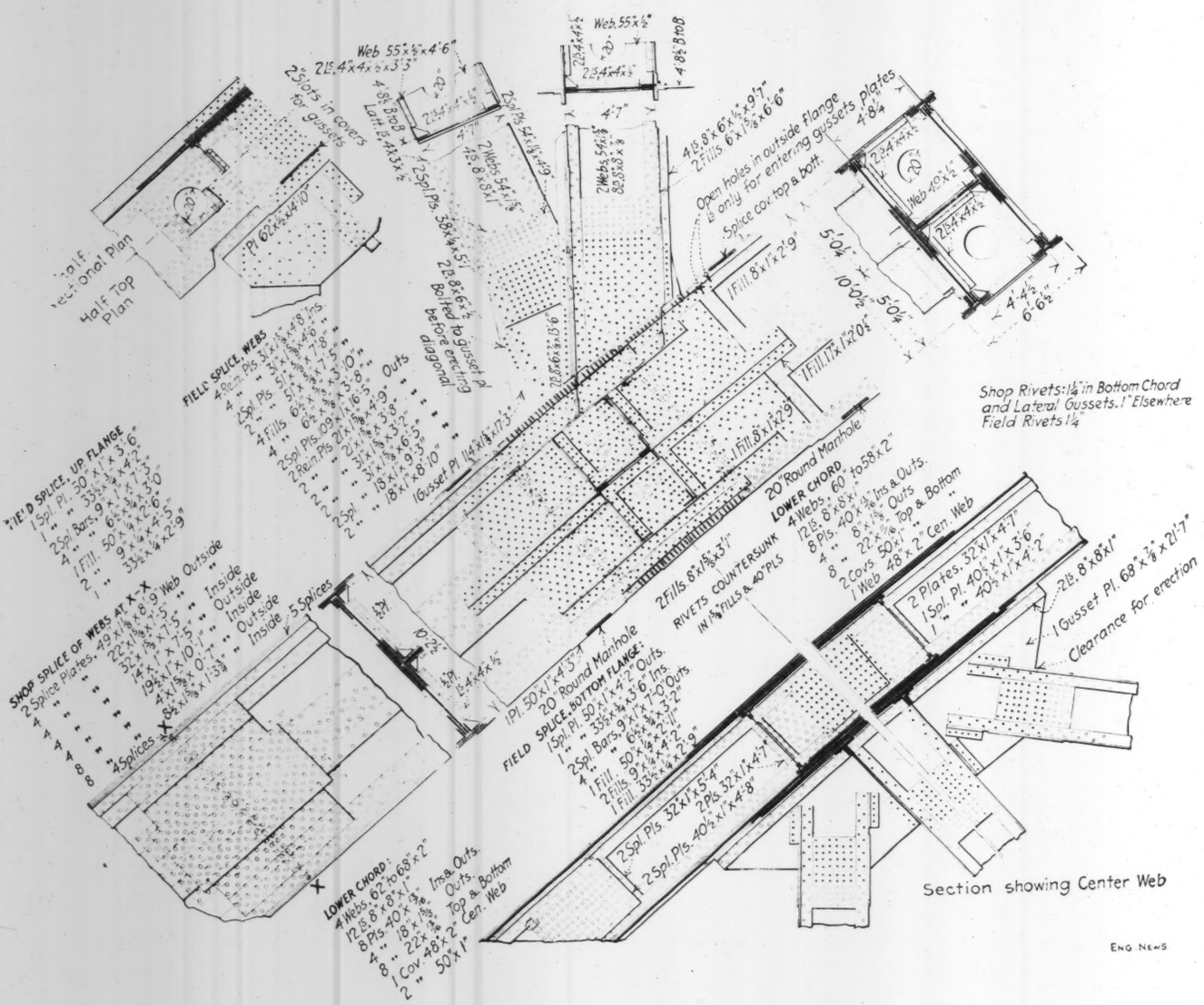

Half Sectional Plan
Half Top Plan
Shop Rivets: 1¼" in Bottom Chord and Lateral Gussets. 1" Elsewhere
Field Rivets 1¼
Section showing Center Web
ENG. NEWS

FIG. 4. ASSEMBLY OF PANEL-POINT 2, BOTTOM CHORD, HELL GATE ARCH

RIVETING

Suiting the great thicknesses of material used, the riveting will be done with 1¼-in. rivets. This, of course, means drilling in the heavier members. Punching is allowed in material ⅝ in. and less in thickness.

Riveting is to be done by power riveters wherever possible, and pneumatic hammers where machines cannot be used—hand riveting will not be allowed.

MATERIAL

For the entire bridge, a steel of higher strength than usual has been specified. The required strength is 71,000 lb. per sq.in., with an allowed range from 66,000 to 76,000. This means about 0.3% carbon steel—a material radically different from ordinary structural steel, but at the same time not appreciably more expensive.

The specifications for this steel are of interest. Either

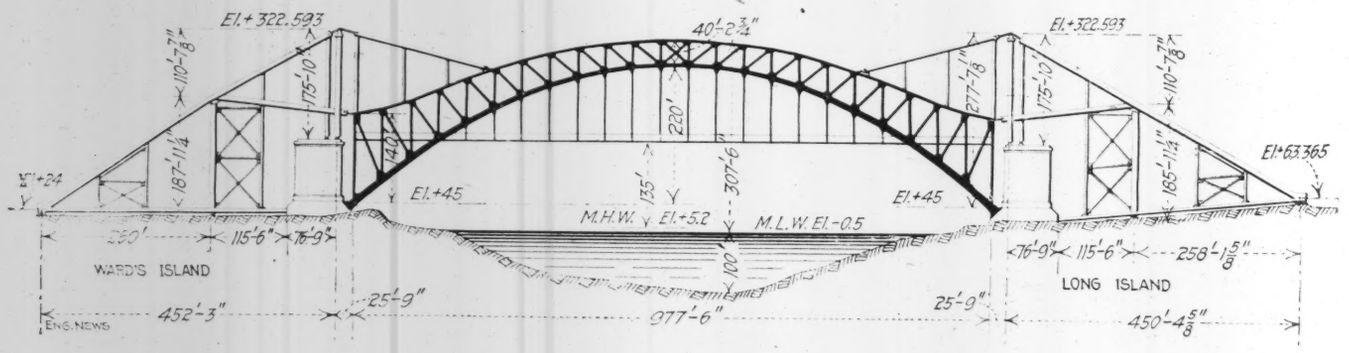


FIG. 6. SKETCH OF METHOD OF ERECTING HELL GATE ARCH

asic or acid steel may be used. For the former, the hosphorus limit is 0.04%, and for the latter, 0.06%. The sulphur limit in either case is 0.05%. In mechanical properties, an elongation of 1,400,000 lb. divided by ultimate strength is called for. This means a trifle under 20% elongation for the desired strength of 71,000. A cold-bend test of 180° around a mandrel whose diameter is twice the thickness of the piece is called for.

All rivets are of ordinary rivet steel.

Roadway

A novel roadway structure is used; namely, a reinforced-concrete trough filled with ballast in which the track ties are embedded.

The inspection footways are floored with wooden planking.

Loads and Stresses

Loads—The bridge is designed for four lines of a railway loading practically equivalent to Cooper's E-60 loading. Separated or continuous trains in any position on any or all of the four tracks were assumed, as necessary to give maximum stresses. The average dead-load of the arch bridge amounts to 53,000 lb. per lin.ft.

The assumed wind load is 30 lb. per sq.ft. on the exposed surfaces of the unloaded bridge, as a distributed fixed load, and 500 lb. per lin.ft. bridge as a moving load.

In computing the vertical load stresses, impact allow-

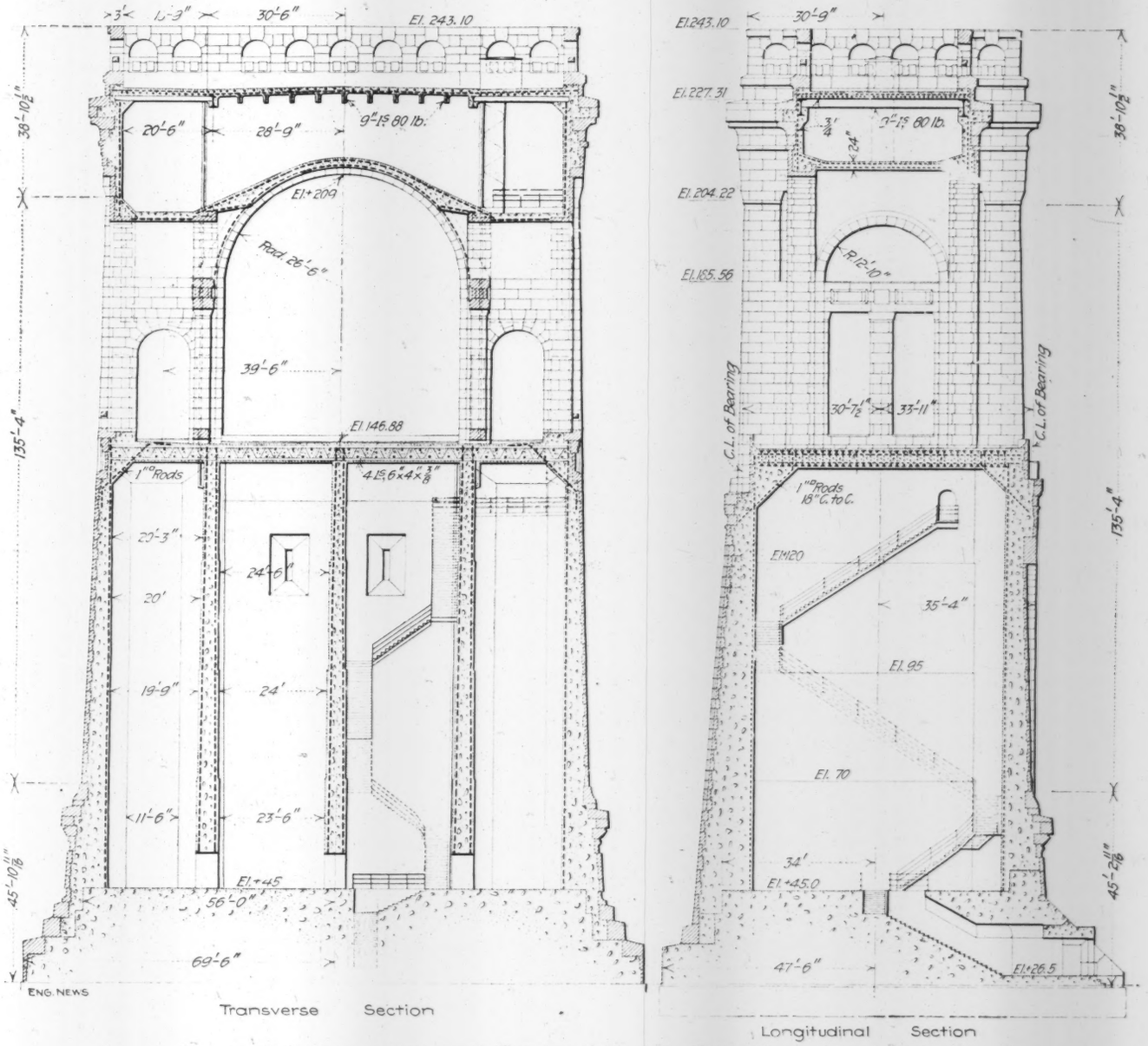


Fig. 7. Reinforced-Concrete Terminal Tower, Hell Gate Arch Bridge

The main stringers of the floor carry 8-in. transverse I-beams, 15 in. apart. Between and on top of these the reinforced-concrete slab of the track trough is built. There is an independent trough for each track, and its length in each case is equal to the clear distance between floorbeams. On the top flange of the floorbeams the ties rest directly on the steel on account of limited height.

ance was made for the live-load according to Lindenthal's impact formula,* which is,

$$I = \frac{L^2}{L + D} \cdot \frac{8\,Q + qa}{4\,Q + 4\,qa}$$

where

*See "Engineering News," Aug. 1, 1912, p. 216, Gustav Lindenthal, "A New Impact Formula."

l = Stress equivalent of the impact;
L = Live-load stress;
D = Dead-load stress;
Q = Weight of locomotives and tenders;
and qa = Weight of train behind tender.

STRESSES—In computing stresses, the dead-load stresses were computed for a three-hinged arch. Live-load stresses were computed for a two-hinged arch, using the method of elasticity. For the computation of wind stresses, in view of the multiple indeterminateness of such a structure laterally, certain simplified assumptions were made. All minor stresses were fully computed: those due to temperature, those due to the drag of braked trains, those due to wind stresses, and those due to lateral impact. These minor stresses are of considerable importance in so large a structure.

The maximum combination of stresses, including impact, amounts to from 20,000 to 24,000 lb. per sq.in. in different members. Secondary stresses due to the distortions of the framework were found to be negligible.

ERECTION

The cantilever method of erection is to be used. Fig. 6 sketches the arrangement in concise form. The first attachment of the anchor chain will be to the end of the upper chord. When the overhang becomes such as to exceed the limit of pull at this point of attachment, a second attachment will be made to the outer end of the arch, and the first attachment slacked away. This second attachment will be adequate for erection to junction at the middle. The back end of the anchorage frame will be counterweighted in proportion to the weight of the half arch.

As accurate fit is a vital matter, the parts of the arch will be laid out horizontally in the shop, in true relative position, and the connection holes drilled. The truss diagram, according to the dimensions given on the drawing, is that which will be realized under full dead-load; this requires that the length of the various members must be corrected in fabrication by the amount of the dead-load compression or elongation, but in opposite direction. The roadway of the arch is to be cambered additionally (in the hanger lengths), to cover the maximum deflection for dead-load, live-load, and temperature.

Novel problems will arise in the erection of the parts of the arch. The heaviest members very greatly exceed the maximum weight heretofore hoisted in bridge erection. The heaviest bottom-chord section weighs nearly 200 tons—more precisely, 182 tons; this is the section whose cross-section is 1385 sq.in. The floorbeams weigh 86 tons each.

The erection will be handled by two travelers, one working on the roadway and one working on the top chord.

Junctioning the arch at the crown will offer no particular difficulty, as a simple butting joint is made—a virtual or temporary hinge—of the same construction as already shown for the intermediate splice joints of the chord. This joint will be maintained open (i.e., as a hinge) until all steelwork is in place, including the hangers and all of the floor and laterals. Then it is to be riveted up and upper chord members placed, thereby converting the arch into a two-hinged structure.

The total weight of steelwork in the arch will be about 19,000 tons.

PORTAL TOWERS

The end towers of the bridge with their enormous weight are essential for the stability of the arch and form at the same time ornamental terminals and portals. They will be used in erection, serving as supports for the vertical posts or towers of the anchor system; the rear wall of the pier or tower is thickened and reinforced to take this load. Fig. 7 shows vertical sections of the tower. It will be of reinforced concrete with a facing of Maine granite.

The towers are to be built up to the roadway level before erection of the steelwork, and after the erection of the arch and removal of the anchorage posts the superstructure of the piers to the top will be constructed.

The bridge, as already stated, is part of the line of the New York Connecting R.R., which will form a connection between the New York, New Haven & Hartford R.R. and the Long Island R.R. and (via the East River tunnels of the Pennsylvania and Long Island and the Bay Ridge-Greenville car-ferry service) the Pennsylvania R.R., for both passenger and freight service. Samuel Rea is President of the New York Connecting R.R. Gustav Lindenthal, Consulting Engineer and Architect, has designed the bridge and is also acting as Chief Engineer of the construction. O. H. Ammann is Assistant Chief Engineer and H. W. Hudson is Engineer of Foundations & Masonry. The American Bridge Co. has the contract for the steelwork of the arch, the P. Ryan Construction Corporation the contract for the tower bases, and the Snare & Triest Co. the contract for the towers. The caisson foundations for the Wards Island Tower are being built by the railway company itself.

New 90-Lb. Rail Section; Denver & Rio Grande R. R.

During 1913, the Denver & Rio Grande R.R. introduced a new rail section, weighing 90 lb. per yd., and this was first laid on the new 2% low-grade line at Soldier Summit, which supersedes the old line with 4% grade. The rail is shown in Fig. 1. The dimensions are given in the accompanying table, from which it will be seen that the rail section is a compromise between the Am. Soc. C. E. section and the A. R. A. (type A) section.

The splice bars are heavily ribbed at top and bottom. The sectional area is 4.27 sq.in.; moment of inertia, 5.80; section modulus, 2.60. The bars weigh 14.52 lb. per ft., or 61.02 lb. per pair, while the four bolts weigh 5.40 lb. The bars are 26 in. long, with bolt holes spaced 6 in. c. to c. Alternate holes are $1\frac{1}{16}$ in. diameter and $1\frac{1}{16}\times1\frac{5}{16}$ in., the $\frac{15}{16}$-in. bolts being placed with heads alternately inside and outside of the rail. The bolt holes in the rail are $1\frac{3}{16}$ in. diameter.

The tie plates, shown in Fig. 2, are of the flanged type, with four $\frac{3}{16}$-in. flanges to bite into the wood, and a shoulder to resist the outward thrust of the rail. The grooves in the face serve to allow the escape of sand which might work under the rail.

The reasons for adopting this special 90-lb. rail section may be outlined as follows. Practically all rail renewals on this road are made necessary by flange wear on curves so that in designing a rail section, and distributing the metal throughout the section, it was neces-

DIMENSIONS OF 90-L B. RAIL SECTIONS

	D. & R.G. R.R.	A. R. A. (Type A)	A. R. A. (Type B)	A. S. C. E.
	in.	in.	in.	in.
Height	5½	5½	5 11/16	5½
Width of base	5⅛	5⅛	4 11/16	5⅛
Width of head, top			2 3/16	2¾
Width of head, bottom	2 9/16	2 9/16	2 9/16	2¾
Side of head, slope	4°	3°	3°	Vert.
Depth of head	1⅝	1 13/16	1 17/32	1 13/16
Depth of web	2¼	3 3/32	2⅛	2 13/16
Depth of base	1	1	1 1/32	1
Thickness, web	9/16	9/16	9/16	9/16
Thickness, edge of base		⅜	11/64	
Height to center of bolt hole	2 7/16			
Radius, top of head	14	14	12	12
Top corner of head	⅜	⅜	⅜	⅜
Bottom corner of head	1/16	1/16	1/16	1/16
Fillets	⅜	⅜	1/16	¼
Corners of base	1/16	1/16	1/16	1/16
Sides of web	14	14	12	12
Edge of base	Vert.	Vert.	Vert.	Vert.
Fishing angles head and base	14°	4 : 1	13°	13°
Metal in head*	39.5%	36.2%	40.1%	42%
Metal in web*	21.2%	24.0%	19.2%	21%
Metal in base*	39.3%	39.8%	40.7%	37%
Area of cross-section, sq.in.	8.86	8.82	8.87	
Moment of inertia	35.36	38.70	32.30	
Section modulus	11.90			
Distance base to neutral axis	2.53 in.	2.54 in.	2fi	

* In the Denver & Rio Grande R.R. rail the distribution of area is as follows: head, 3.50 sq.in.; web, 1.87 sq.in.; base, 3.49 sq.in.; total, 8.86 sq.in.

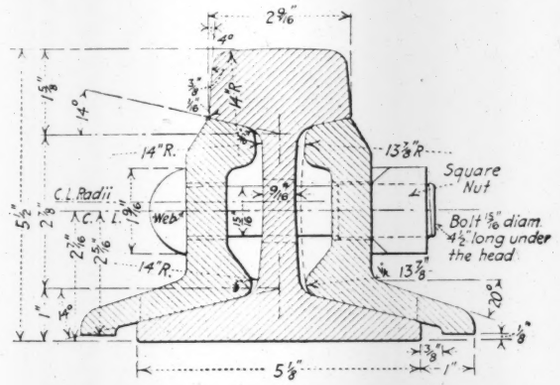


FIG. 1. NEW 90-LB. RAIL SECTION AND SPLICE BARS; DENVER & RIO GRANDE R.R.

sary to assign as much area to the head as was consistent with other features.

The objections to the Am. Soc. C. E. section were its wide thin base and its extra width of head in comparison to its thickness. As to the A. R. A. (type A) section, it was considered that with the small proportion of area in the head this section would have a very short life on this road. The objections to the A. R. A. (type B) section were lack of vertical stiffness and the difficulty of designing a stiff splice bar, owing to the low height of the space between the web and base. A most important consideration in the design of a rail is the height of angle-bar which it is possible to secure.

With the above mentioned factors in view, the problem was to design a rail having the following three principal characteristics, giving due weight to practical and mechanical considerations in its manufacture: (1) vertical stiffness; (2) large area of head, with special consideration for wheel flanges encroaching on top of angle-bar during process of curve wear; (3) stiffness of joint bars. Some secondary requirements which also had to be borne in mind were as follows: (1) a minimum juxtaposition of the neutral axis and center line of bolt holes; (2) a material thickness of base at the edge, so as to form a considerable area of contact between the edge of the base and the shoulder of the tie-plates; (3) maximum fishing angles consistent with good practice, so as to insure better working of the material during the process of rolling.

A study of the section shown in Fig. 1 will indicate how nearly these requirements have been met, and attention may be called to a few of the salient features of the new design. The thickness of the head is considered to be amply sufficient when compared with the actual section of worn rails. The height of rail, when compared with width and thickness of base, was all that could be obtained without increasing the weight of the section, and it is felt that the design gives a fairly stiff rail. The height gives 2⅞ in. vertical dimension of web and while a greater web height would have been desirable in favoring the stiffness of the angle splice bars, this was all that could be obtained in giving due consideration to other requirements.

The fishing angles are made 14°, instead of the 13° which is customary with the majority of rail sections, to insure better working of the metal in the rolls. The center line of bolt holes is less than $\frac{1}{10}$ in. below the neutral axis. The edge of the base is ⅜ in. thick. The area of the web at its connection with the base is increased by placing the centers of radii of the sides of the web above the horizontal center line of the web and making the connecting radii ⅜ in., as well as by using a 14-in. radius for the sides.

It will be noted that the angle bar is designed with a large overhang so as to clear the shoulder on the tie-plate. This permits the universal use of one type of tie-plate; that is, there is no distinction between joint, intermediate, right-hand and left-hand tie-plates. The tie-plates are punched with four holes to fit the stagger of

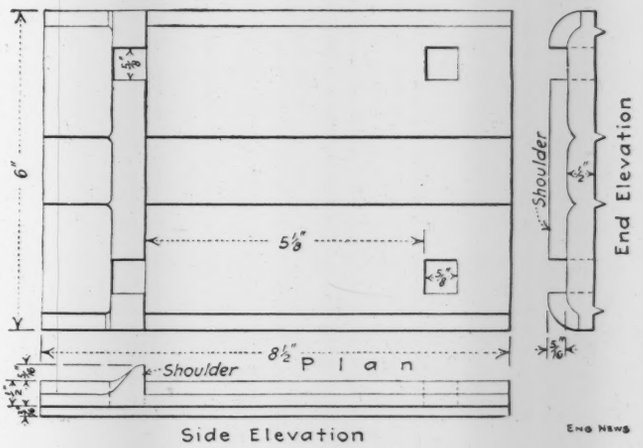


FIG. 2. STEEL TIE-PLATE WITH BOTTOM FLANGES AND TOP SHOULDER; DENVER & RIO GRANDE R.R.

the spike slots in the angle bars, and therefore any plate can be used on any tie, whether at a joint or at intermediate points and on either side of the track.

The rails were rolled by the Colorado Fuel & Iron Co., and we are informed that the makers are very well pleased both with the facility in rolling and with the character of the product as it came from the rolls.

Locomotives Furnished Power during the replacement of a battery of worn-out boilers, at the plant of Schaum & Uhlinger, Inc., of Philadelphia, Penn., according to Fletcher Schaum. Two "American" type locomotives were rented from the Pennsylvania R.R., and while these were in operation the old battery of two boilers was replaced. The locomotives, whose connecting-rods and valve-gears had been disconnected, were hauled to a convenient point on a siding of the plant; their throttle valves were closed, and a connection piped from their auxiliary steam-domes over the fireboxes to the main steam headers in the plant.

Designing Water Conduits of Large Diameter

By A. C. Janni*

A vertical pipe containing water, or a horizontal pipe containing a weightless fluid under pressure, is exposed to uniform internal pressure, and experiences only tension in its circular elements. But in a horizontal pipe containing water the internal pressure is much less at the top than at the bottom, and the stresses in a circular element are not purely tensile, but comprise a tension and a bending moment. In large pipes, or conduits, the bending moments become determinative. Necessarily the design of such a conduit is radically different from the procedure of designing for simple tension.

A common method of dealing with the problem of designing large pipes has been to add a constant to the thickness of wall determined by the hydrostatic tension; thus, wall thickness t is

$$t = c + \frac{rp}{sc'}$$

Where

r = radius of conduit;
p = hydrostatic pressure at the horizontal center of the conduit;
s = maximum allowable stress in the material;
c and c' = constants.

This is but a modification of the formula for pure tensile action (Mariotte's formula), as when $c = o$ and $c' = 1$, the formula becomes

$$t = \frac{rp}{s}$$

In the case of very large conduits, this method of design is quite inadequate.

Within the last few years, there is a marked tendency toward the use of very large conduits, in order to meet modern industrial needs. Moreover, such conduits are usually built of reinforced concrete. In Norway, for instance, it is rather common at present to build water conduits with diameters from 10 to 13 ft. and hydrostatic pressures from 30 to 100 ft. At Scotsos there is a water conduit of 16.5 ft. diameter and about 26.5 ft. hydrostatic pressure. Conduits of these dimensions require careful design.

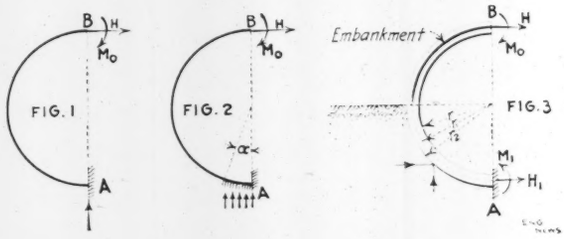
It is enough to think of the conduit being full of water, without hydrostatic pressure above the top of the pipe, to realize the importance of the bending moments in the wall of the pipe due to the weight of the water filling the pipe. This condition, which occurs every time the conduit is filled or emptied, produces the maximum tendency to distortion from circular form. Since reinforced concrete has not enough elasticity to adapt itself to important deformations without cracking, it is imperative that the distorting moments be resisted by the bending stress of the cross-section of the pipe wall.†

Little has been written on this important question, and English literature is particularly meager. The principal foreign references are given at the close of this article.

Some writers on reinforced concrete deal with water conduit design, and give formulas founded on the assumption that the ground exerts only vertical reaction, and that the entire reaction is concentrated at the lowest point of the pipe cross-section. This condition would not occur in actual practice, and, therefore, the results err on the side of safety. A large conduit designed by these formulas would be unnecessarily expensive.

Uncovered Conduit

Fig. 1 is a sketch of the half cross-section of a thin conduit, AB being the vertical diameter. Considering the lower point A as fixed, and studying the equilibrium of the piece of pipe wall, the top tension H and bending



moment M_0 at point B can be determined by elastic analysis. The results are:

TABLE I. FORMULAS FOR UNCOVERED CONDUIT SUPPORTED AT MIDDLE OF BOTTOM

Load considered	H	M_0
Weight of water filling the pipe	$\frac{1}{4}$ wr²	$-\frac{1}{4}$ wr²
Weight of pipe	$\frac{1}{2}$ wgstr	$-\frac{1}{2}$ wgstr²

From these formulas the moment and tension at any other point of the ring are easily computed. The formulas apply to a thin-walled conduit resting on a support at its lowest point, and not covered with earth. While they are simple, their use in practice would mean a waste of material.

If the same conduit rests on a saddle whose width is such as to cover the arc a, Fig. 2, the pipe still being without cover, the formulas are not conveniently stated in general form. For any fixed value of a, simple formulas result, however. If $a = 20°$, i.e., the saddle covers a total arc of 40°, which is a fair average, the formulas are:

TABLE II. FORMULAS FOR UNCOVERED CONDUIT SUPPORTED ON 40° SADDLE

Load considered	H	M_0
Weight of water filling the pipe	0.73055 wr²	−0.24071 wr³
Weight of pipe	0.46110 wgstr	−0.48142 wgs²r²

In these formulas, the symbols have the following meaning:

r = radius of pipe, ft.;
w = weight of water, lb. per cu.ft. = 62.33;
g_s = specific gravity of the pipe material;
t = thickness of the pipe, ft.;
H = tension at top of pipe, lb. per lin.ft.;
M_0 = bending moment at top of pipe, ft.-lb. per lin. ft.

*Consulting Engineer, 28 West 46th St., New York City.

†This matter is just as important in large steel pipes, as was well illustrated in the noteworthy failure of a 14-ft. conduit at Balleville, Ohio, last winter (see "Engineering News" of Apr. 27, 1913, p. 909).—Editor.

Covered Conduit

It is usual practice to build large conduits with the lower half bedded in a semicircular entrenchment, purposely excavated following the external radius of the future conduit; and, after the conduit has been built, to cover the upper half of it with a protective earth embankment, more or less thick (Fig. 3). For such a conduit, the following sets of formulas have been computed,

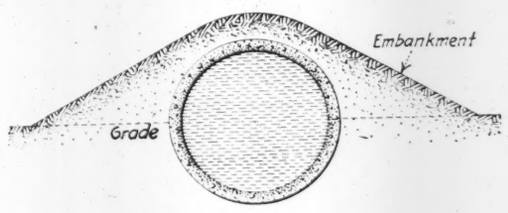


FIG. 4

according to Guidi's method. The mathematical working-out of the formulas is omitted, but the assumptions made in finding the values of H and M_0 are stated.

The values are given separately for five separate items of loading:

1. Weight of water;
2. Weight of the conduit;
3. Weight of the embankment;
4 and 5. Reaction of the soil.

1. The hydrostatic pressure acting upon the conduit walls is due to the water head outside the conduit as well as to the water head of the liquid inside the conduit itself. The latter, neglected in small pipes, is very important in large conduits. The outside water head produces only pure tension, which can be calculated by means of Mariotte's formula and is constant for all points of the cross-section of the conduit. The stresses due to the inside water head are variable and are determined by means of the formulas given below; they must be added to the stresses due to the first cause.

2. The formulas for the stresses due to the weight of the conduit itself have been found on the assumption that the material of the conduit is concentrated along its middle circle.

3. The formulas for the stresses due to the load of the earth cover on the upper half of the conduit have been found on the assumption that the *weight of the earth cover is equal to the weight of the upper half conduit,* and is concentrated along the middle circle of the cross-section of the upper half conduit.

The evaluation of the reaction of the ground against the lower half of the conduit is by far the most uncertain part of the problem, on account of uncertainties due to the variable nature of soil and its static indetermination. Any strictly mathematical solution could give but illusory results.

Let us divide the reaction of the ground at any point of the lower half of the pipe into a horizontal and a vertical reaction.

4. *Horizontal Reaction*—Concerning the horizontal reaction, it is to be observed that, while the horizontal thrust (*active pressure*) of the embankment increases from the top of the embankment to the bottom of it, the horizontal reaction (*passive pressure*) arising from the tendency of the conduit to flatten its circular shape increases from the bottom to the top. Therefore, it seems permissible to *assume that the horizontal reaction is uniformly distributed upon the vertical projection* of the lower half conduit. This assumption, however arbitrary, cannot have a great influence on the results, as it is a good rule of designing not to depend on more than one-fifth of the passive pressure, for an ordinary soil. The formulas given have been found on the assumption just stated with a coefficient of safety of 5.

5. *Vertical Reaction*—Again considering the tendency of the conduit to flatten its shape, it is logical to assume that the vertical reaction increases from the bottom of the trench to its top (middle of depth of pipe). For safety, however, formulas are given on two assumptions: (A) Vertical reaction equally distributed on the horizontal projection of the external surface of the lower half conduit; and (B) Vertical reaction increasing from zero at the bottom to a maximum at the top. The actual conditions probably lie somewhere between these two assumptions.

Referring to Fig. 4, let

w = weight of water, lb. per cu. ft.;
g_c = specific gravity of concrete;
g_e = specific gravity of earth;
r = internal radius of conduit, ft.;
r_1 = median radius of conduit, ft.;
r_2 = external radius of conduit, ft.;
t = thickness of wall, $= r_2 - r$;
q_v = intensity of vertical reaction when uniformly distributed over the horizontal projection, lb. per sq.ft.;
q' = intensity of vertical reaction at top of trench (midheight of conduit) when the reaction varies from zero at bottom to maximum at top, lb. per sq.ft.;
H = tension at top of conduit, lb. per lin.ft.;
M_0 = moment at top of conduit, ft.-lb. per lin.ft.

From what has been said as to assumed weight of earth cover, the total load on the foundation is

$$\pi r^2 w + 3\pi r_1 t w g_c$$

and the pressure q_v is

$$q_v = \frac{\pi w r}{2}\left(1 + 3\frac{r_1}{r}\frac{t}{r}g_c\right)$$

For varying vertical reaction, the maximum (q_v') will be twice the average, or

$$q'_v = 2\,q_v = \pi w r\left(1 + 3\frac{r_1}{r}\frac{t}{r}g_c\right)$$

The horizontal reaction is computed as the passive pressure on a vertical surface, on the basis of 37° angle of repose, and one-fifth of the computed value is taken.

The general formulas are given in Table III.

TABLE III. GENERAL FORMULAS FOR COVERED CONDUIT

Load considered	H	M_0
1. Weight of water filling the pipe	$\frac{1}{4}\,w\,r^2$	$-\frac{1}{4}\,wr^2r_1$
2. Weight of pipe	$\frac{1}{2}\,wger_1t$	$-\frac{1}{2}\,wger_1^2t$
3. Weight of earth cover	$\frac{1}{4}\,wger_1t$	$-\frac{1}{4}\,wger_1^2t\left(\frac{8}{\pi}-1\right)$
4. Horizontal reaction of earth	$-\frac{8}{15}\,wge\frac{r_2^2}{\pi}\left(1-\frac{r_2}{2r_1}\right)$	$\frac{7}{5}\,wger_2^3\left[\frac{4}{3\pi}\left(\frac{r_1}{r_2}-\frac{1}{2}\right)+\frac{1}{4}-\frac{r_1}{4r_2}\right]$
5. Vertical reaction, equally distributed	$-\frac{2}{3}\,qvr_2\left(\frac{r_2}{r_1}-\frac{1}{2}\right)$	$\frac{1}{2}\,qvr_2^2\left[\frac{r_1}{r_2}\left(\frac{4}{3\pi}-\frac{1}{2}\right)+\frac{4}{3\pi}-\frac{1}{4}\right]$
6. Vertical reaction varying	$-\frac{1}{2}\,\frac{q'vr_2}{\pi}\left(\frac{r_2}{r_1}-\frac{1}{2}\right)$	$\frac{1}{8}\,q'vr_2^2\left[\frac{13}{3\pi}-1-\frac{r_1}{2r_2\pi}\right]$

Note: For items 1, 2 and 3, the vertical reaction is assumed concentrated at middle of bottom. For items 5 and 6 the entire vertical load is assumed concentrated in the vertical center-line. In combining either 5 or 6 with one or more of items 1, 2 and 3 the assumed concentrated reactions and loads neutralize.

These are *general formulas* for large conduits, under the assumptions previously stated.

If $t = 0.15r$, which means that $r_1 = 1.075r$ and $r_2 = 1.15r$; and taking $w = 62.33$ lb., $g_c = 2.5$, $g_e = 1.8$, the formulas have the following numerical value:

TABLE IV. VALUES OF CONDUIT FORMULAS FOR A MEAN VALUE OF THICKNESS

Load considered	H	M_o
1. Water	$46.7475\ r^2$	$-16.7543\ r^3$
2. Pipe	$12.5657\ r^2$	$-13.5069\ r^3$
3. Earth cover	$6.2828\ r^2$	$-10.4340\ r^3$
4. Horizontal reaction	$-11.7180\ r^2$	$5.1734\ r^3$
5. Uniform vertical reaction	$-26.1474\ r^2$	$12.8960\ r^3$
6. Varying vertical reaction	$-39.2242\ r^2$	$19.1103\ r^3$

The algebraic sum of 1-5 will give the total value for the assumption of vertical reaction uniformly distributed (*Hypothesis A*); the algebraic sum of 1-4 and 6 will give the values for varying vertical reaction (*Hypothesis B*). These totals are:

TABLE V. TOP TENSION AND MOMENT IN MEAN CONDUIT, FOR TWO HYPOTHESES

	$\frac{H}{r^2}$	$\frac{M_o}{r^3}$	$\frac{1}{r}\frac{M_o}{H}$
Hypothesis A	27.7306	−22.6257	−0.816
Hypothesis B	14.6537	−16.4114	−1.120

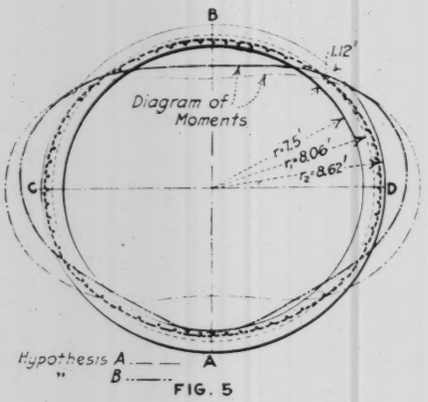


FIG. 5

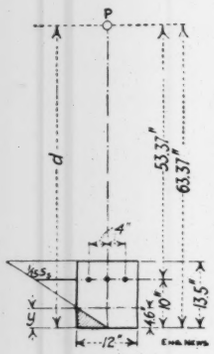


FIG. 6

FIG. 5. MOMENT DIAGRAMS FOR COVERED CONDUIT ON TWO ASSUMPTIONS AS TO VERTICAL REACTION

FIG. 6. STRESS DIAGRAM FOR BOTTOM SECTION OF CONDUIT

From H and M_o the values of the tension and moment at the bottom of the conduit (H_1, M_1) can be computed. They are summarized for the two hypotheses as follows:

TABLE VI. BOTTOM TENSION AND MOMENT FOR TWO HYPOTHESES

	$\frac{H_1}{r^2}$	$\frac{M_1}{r^3}$	$\frac{1}{r}\frac{M_1}{H_1}$
Hypothesis A	37.5787	−23.9970	−0.639
Hypothesis B	50.6555	−4.4316	−0.087

The two sets of numerical values given in the last two tabulations enable the designer to compute rapidly the tensions and moments in the pipe. The stresses in the concrete and the steel of the conduit are determined from these.

APPLICATION

The above formulas have been applied to the case of a circular reinforced-concrete conduit 15 ft. in diameter and under 30-ft. head of water over top of pipe. The design, shown in Fig. 5, was made for Hypothesis *A*, but tension polygons (or bending-moment diagrams) are given for both *A* and *B*. In the polygons the ordinates are radial, and represent the value *M*; the positive values are laid off outside, negative values inside the conduit.

The diagrams show very clearly the influence of the assumption as to distribution of vertical reaction. They also give a graphical indication of the proper position of the ring reinforcement.

INFLUENCE OF HEAD OF WATER

Fig. 6 sketches the cross-section at *A* of the conduit, for one foot length along the pipe. The point of application of the tension *H* on this section is marked *P*.

A diagram of the stresses (compression in concrete and tension in steel) is also drawn. The compression in the concrete is 484 lb. per sq.in., and the tension in the steel is 8523 lb. per sq.in. when the water head *h* is zero, the conduit being just full of water. Under a head of 30 ft. over top of pipe the compression in the concrete becomes 402 lb. per sq.in. and the tension in the steel reaches 13,422 lb. per sq.in.

In the following are tabulated the values of *d*, *y*, s_c and s_s, for various heads of water up to 70 ft.

TABLE VII. STRESSES IN BOTTOM SECTION OF CONDUIT UNDER VARIOUS HEADS

h, ft.	H, lb. per lin.ft.	$d = \frac{M_1}{H_1}$, in.	y in.	s_c lb. per sq.in.	s_s lb. per sq.in.
0	2,119	63.37	4.60	484	8,523
10		24.37	4.10	469	9,907
20		17.17	3.50	443	12,341
30	16,143	14.15	3.10	402	13,422
40		12.37	2.62	354	14,534
50		11.40	2.16	296	16,115
60		10.68	1.59	227	18,010
70		10.08	0.59	80	19,189

The above remarkable results show that as the head on the conduit increases, the compressed section of the concrete decreases, and the stresses in the concrete decrease rapidly; the stress in the steel, on the other hand, increases with the head. The tensile strength of the concrete being neglected, as in usual practice, we can say that *the steel and the concrete are not stressed in constant proportion,* but the support of the concrete decreases just when the steel is increasing its working stress.

In designing a large conduit such a ratio of reinforcement should be used that when the steel reaches its maximum stress there is still some compression in the concrete. This will prevent the formation of cracks through the conduit walls, which would mean leakage.

For similar reasons the stress in the steel should be kept somewhat lower than is allowed for other kinds of reinforced-concrete construction.

REFERENCES

The following references to analytical treatment of large conduits may be useful:

Birault C., "Génie Civil," 1902-1903.

Forchheimer Ph., "Zeitschrift d. Oesterr. Ing. u. Arch. Vereines," 1904.

Alibrandi P., "Sul calcolo statico dei tubi," Annali della Società degli Ing. ed Arch. Italiani, Roma, 1905.

Guidi C., "Sulla stabilità delle condotte d'acqua con tubi di grande diametro," Atti della R. Accademia delle Scienze di Torino, 1912.

Goupil C., "Sur la stabilité des conduits d' eau de grand diamètre," Annales des Ponts et Chaussées, 1912.

The Philadelphia City Planning Exhibit at the recent International Exposition at Leipzig, Germany, won an award of a silver medal and diploma. The city of Lyons, France, has requested the exhibit for its International Exposition, which is to begin in May, 1914.

Excessive Rainfall at Galveston, Tex., 1898-1913

By A. T. Dickey*

The accompanying rainfall table for the city of Galveston, Tex., was compiled from United States Weather Bureau records and covers a period of 16 years —from Jan. 1, 1898, to Dec. 31, 1913.

EXCESSIVE RATES OF RAINFALL IN THE CITY OF GALVESTON, TEX., JAN. 1, 1898, TO DEC. 31, 1913

(Compiled by A. T. Dickey, City Engineer, from records of the U. S. Weather Bureau)

Duration, min.	Number of downpours at various rates (in.) per hr. 1.0 to 1.5	1.5 to 2.0	2.0 to 2.5	2.5 to 3.0	3.0 to 3.5	3.5 to 4.0	4.0 to 4.5	4.5 to 5.0	5.0 to 5.5	5.5 to 6.0	6.0 to 6.5
10	36	45	37	20	17	7	3	1	1	1	3
20	37	43	31	14	10	6	1	1	1	1	
30	45	32	19	7	5	2	2	1	1		
40	17	22	5	5	1	1	1		1		
50	20	10	7	2	2	1				1	
60	20	6	6		3	1	1		1		
80	12	5	2	1	2						
100	6	2	2		2						
120	8	2			1	1					

The purpose of this compilation was to determine the maximum amount of rainfall for which provision should be made in designing storm sewers. The table shows the intensity of rainfall for given durations, and by inspection one can determine from it the probable recurrence or frequency of severe storms, so that the design of sewers may be made to suit the conditions existing in each area to be served.

Two or three phenomenal downpours have occurred during the period covered by this record, which are so unusual that they will not and should not be considered in our future design on account of the extraordinary expense that would be required if they were provided for. A casual inspection of the table, without an explanation, would lead one to believe that a great many more very heavy rains have visited Galveston than have occurred: For instance, on Oct. 22, 1913, we had 12.19 in. of precipitation in 12 hr.† This storm appears on the table as follows:

5.3 in. of rainfall in 60 minutes.
5.7 in. average rate per hour for 50 minutes.
3.2 in. average rate per hour for 100 minutes.
2.5 in. average rate per hour for 120 minutes.

The idea was to show intensity and duration of excessive rainfall, rather than a complete history of each storm.

The three heaviest rains on record in the City of Galveston occurred as follows:

14.35 in. in 24 hours on July 13 and 14, 1900.
14.1 in. in 24 hours on Oct. 7 and 8, 1901.
12.19 in. in 12 hours on Oct. 22, 1913.

During the storm last mentioned, all storm-water sewers were overtaxed, the amount of runoff being at least twice as heavy as that for which the sewers were designed. The percentage of runoff was practically 100, and the amount allowed for in the design was about 40% of a 2-in. rainfall per hour.

This rain, although almost unprecedented in intensity and duration, did very little damage in the city except on account of cessation of business during the downpour. From 11 a.m. to 7 p.m., the water was from 8 in. to 24 in. deep in the business section, but the streets were practically dry within four hours after the rain ceased. In the lowest and unpaved portions of the city, traffic was resumed in less than 24 hr. The city's streets were damaged on unprotected slopes in the amount of about $2000. Considerable damage occurred to merchandise stored on floors below high-water mark. No approximate estimate has been made of merchandise damage, but in all probability it did not amount to more than $10,000.

Such a rain storm may be expected three or four times in a period of forty years, and it is doubtful if it would be good business policy on the part of the city to attempt to provide for such unusual conditions.

The City of Galveston is built upon the eastern end of an island, having a slope of 1 ft. in 1600 ft., from the Gulf of Mexico to Galveston Bay. The width of the island occupied by the city varies from one mile at its eastern extremity to about three miles at the western city limits. The entire area of the city drains northward to Galveston Bay and on account of the flat gradient and low elevation, the disposition of storm water is very difficult. The business section, and a considerable area adjacent thereto, are served by storm sewers that are competent to dispose of any rainfall except extraordinary precipitation, such as occurred on Oct. 22, 1913. The residence section generally has surface drainage only and during excessive rainstorms the streets and sidewalks are sometimes considerably overflowed. When the runoff exceeds the capacity of the sewers the surface water flows over the railway and wharf company property, lying north of the city, into the bay, and a safety valve is thus provided. There is therefore very little probability of any high water ever exceeding the mark set during the last storm. Some improvements are needed in the way of surface drainage, or additional storm sewers to more promptly drain the business section and some districts in the residence section, but there is no very serious trouble existing at present.

*City Engineer, Galveston, Tex.

†A few other details of this and some other heavy rainfalls of Galveston were given by Mr. Dickey in our issue of Nov. 6, 1913.—Ed.

What the Public-Works Engineer Should Be—Some valuable pointers on this subject are given by Warwick Greene, chief of the Bureau of Public Works of the Philippine Islands, in the October issue of the Bureau's "Quarterly Bulletin." While they are drawn for the guidance of the members of the Bureau's own corps in their dealings and contact with the Philippine people, they will apply with equal force to city, county and public-works engineers in the States.

The public's good will rests on confidence in the work done by the Bureau and on liking and respect for its men. Unless the Bureau is popular and respected, appropriations are grudgingly granted, local officials do not cooperate, and the general public is quick to deride the smallest shortcomings in the management of the Bureau.

This good will is created by two things—efficient work by the Bureau and a popular personnel—and both are necessary. Good work in public works is its own justification to the engineering profession and eventually to the public; but public recognition of the same is enormously accelerated if the engineers and employees are likeable men, well thought of in the community.

The kind of man we want is alert, capable, energetic, enthusiastic, companionable. A man of clean ideals and a "good sport" in the right and not the wrong sense of the word. A man whose enthusiasm for life in general and his work in particular are contagious; who is on genial terms with his associates, official and others; who believes that public works are one of the greatest needs of the Islands; who makes other people believe the same; whose treatment of the public is always courteous and considerate; who leaves rudeness and insolence to the other fellow; who is thoroughly in sympathy with the people he is working among; and who convinces everybody that he is striving heart and soul to make every peso for public works go as far and do as much as possible.

We do not want the pessimist, the grouchy, disgruntled cuss, the fellow who always knows more than his chief, who whines about favoritism and "pull," forgetting that the man who gets results is always the favorite in a live organization.

The public-be-damned business man and public official should be as extinct in modern American life as witch burning or the divine right of kings to misrule. The man who defies or exasperates the portion of the public with which he comes in contact is a traitor to the Bureau, for he is estranging the public which pays our pay roll and on whose good will the Bureau depends.

Foundations for the Morgan Building, New York City

There is now being erected at the southeast corner of Broad and Wall Sts., New York City, an elaborate four-story banking building for the use of the firm of J. P. Morgan & Co. This building occupies the site of the old Drexel Building, an old wall-bearing building with shallow foundations, and is bounded on its south and east sides with the Mills Bldg., another wall-bearing structure. The new building, while only four stories in height, is to be designed so that in the future, if necessary, a 20-story structure may be erected on the present foundations and columns, so that those foundations had to be of much greater size and stability than the four-story structure now being erected calls for. They consist of a continuous coffer-dam wall 7 ft. thick, completely surrounding the lot, on which the wall columns rest and which forms the retaining wall for the cellar excavation, and 19 interior concrete piers, the excavation for which was dug in the open to solid rock from a hardpan level excavated within the caisson-built walls. The excavation for the sub-basement is at an elevation of 52 ft. 9 in. below curb level, whereas water level is only 16 ft. below the same datum. It will, therefore, be seen that the caisson-built wall around the lot had to reach to rock and had to make a completely water-tight structure.

Before sinking the caisson or doing any work on the foundations for the new building, it was necessary to shore and underpin the walls of the adjacent Mills Building. These walls were very heavy, weighing about 10 tons per lin.ft. of wall and were erected partly on piles and partly on the soil 16 to 18 ft. below the curb level.

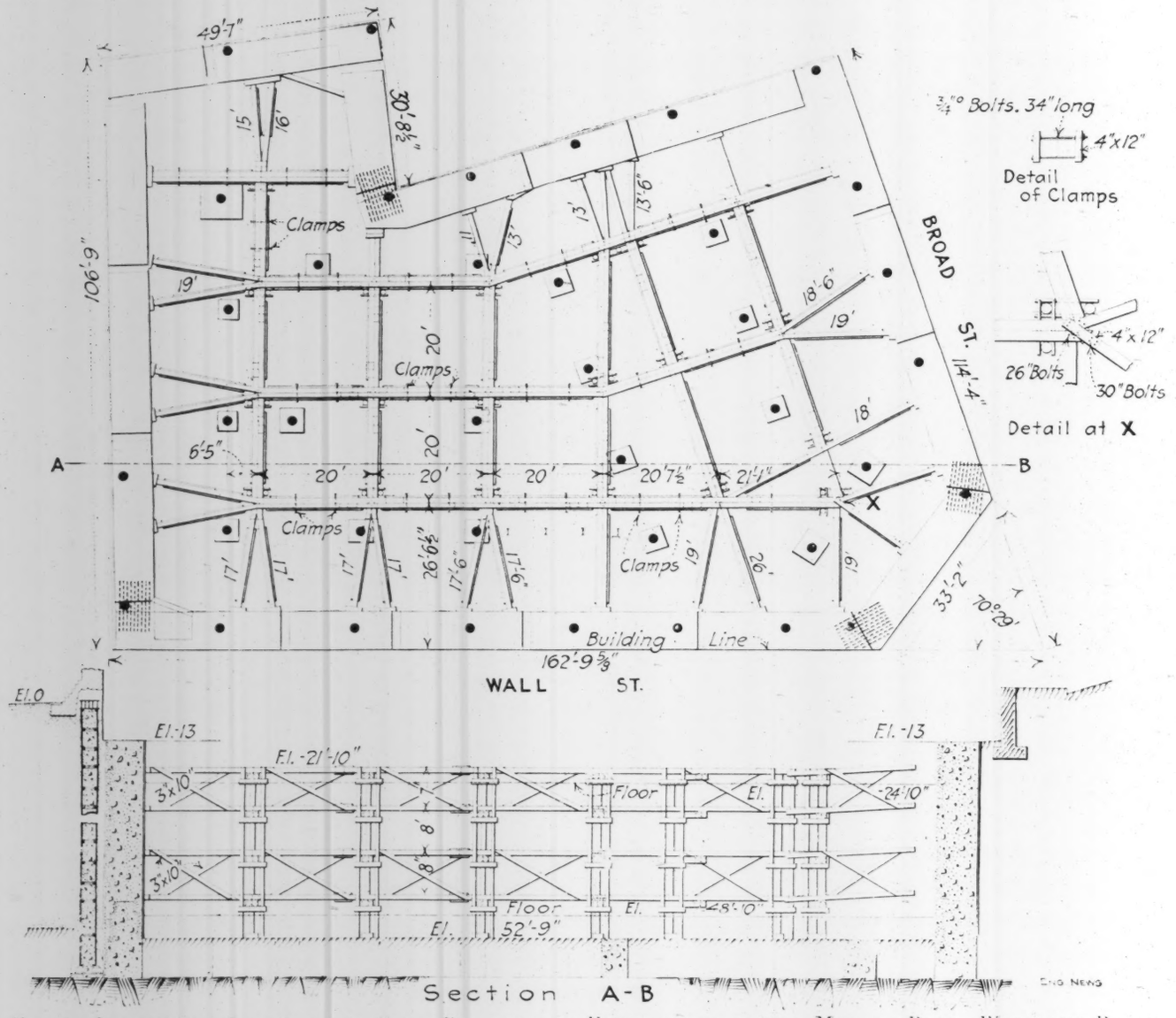


FIG. 1. DETAILS OF CAISSONS AND CROSS-BRACING FOR FOUNDATIONS OF THE MORGAN BLDG., WALL AND BROAD STS., NEW YORK

The underpinning was carried on while the old Morgan-Drexel Building was being razed, so that no time was lost in getting to work on the caisson for the wall after the building was taken down. The method of underpinning the old Mills Building was described in ENGINEERING NEWS, Aug. 7, 1913, p. 257. Briefly, it was accomplished by sinking 19 pneumatic cylinders spaced about 12 ft. apart down to rock 65 ft. below the curb. These cylinders, which were 38 in. in diameter, were made up of 4-ft. and 6-ft. cast-iron sections with ends flanged and bolted together. They were jacked down and excavation

w - made within them under air pressure, the bottom cylinder being used for a working chamber and the next to bottom one for an air lock. The extreme left of the sectional elevation in Fig. 1 shows the general method of carrying down these columns.

After this underpinning had been finished the lot of the new building was excavated to a depth of 13 ft. below the curb, which excavation cleared most of the old footings. At this level the caissons for the exterior wall were started and were sunk therefrom through a layer of quicksand and of hardpan to rock. The average depth of this rock was 60 ft. 2 in., and the greatest depth 65 ft. 5 in. lb. per sq.in. The caissons were sunk 1 ft. 6 in. apart and were later joined together at the end by concrete placed under air in the space between the caissons. As shown in Fig. 1, some of the corners of the caissons were tied together with steel rods.

This forms a continuous concrete wall from an elevation 13 ft. below curb to rock bottom and over 7 ft. wide entirely surrounding the lot. Within this wall the lot was excavated to a depth of 52 ft. 9 in. below the curb. As the excavation progressed, heavy cross-bracing made up of 12x12-in. timbers was placed across the lot abutting against the sides of the coffer-dam. This acted to

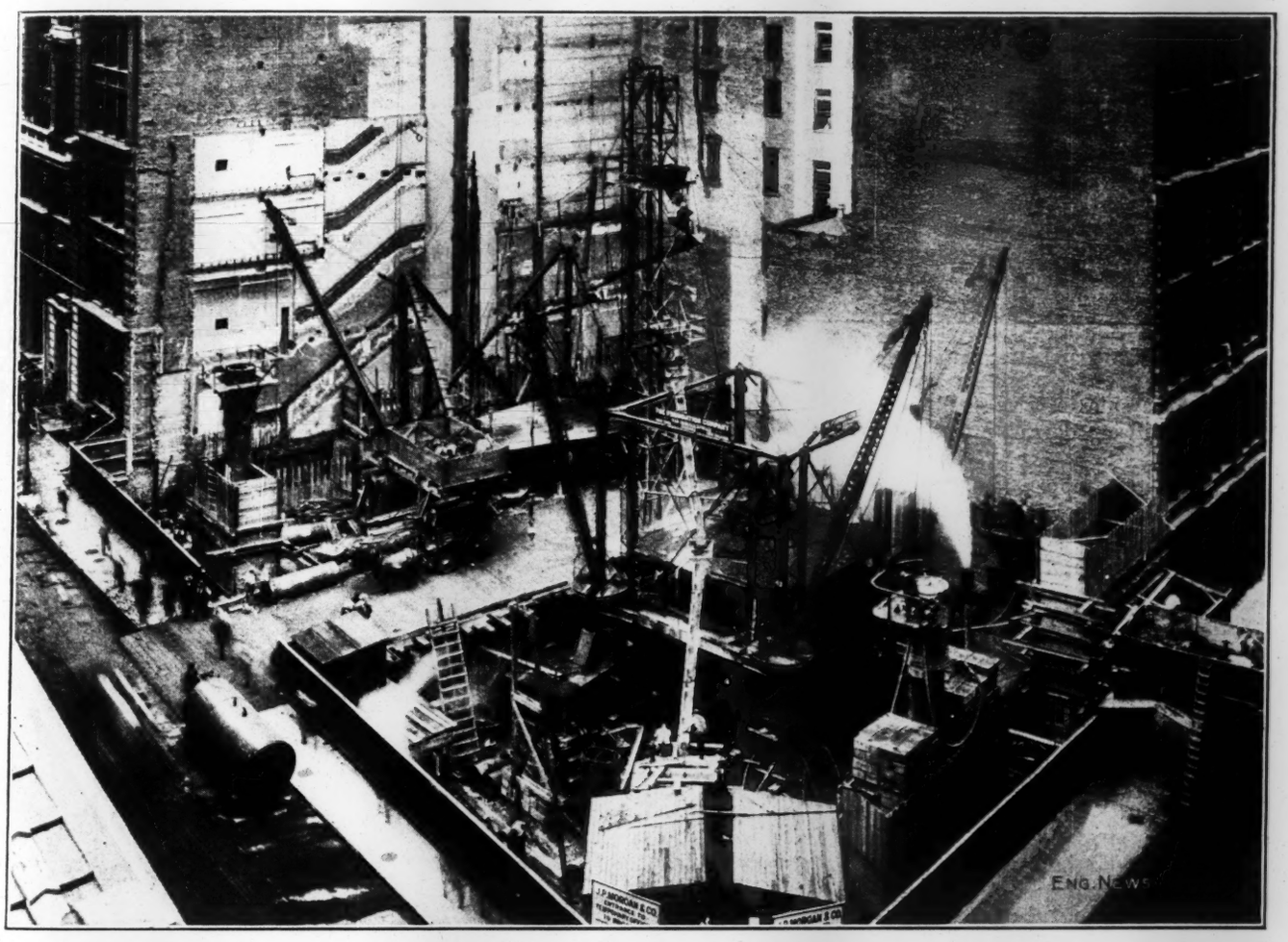


FIG. 2. LOOKING FROM THE CORNER OF WALL AND BROAD STS. INTO THE MORGAN BLDG. FOUNDATION WORK

below the curb. The layer of hardpan varied in thickness from 5 ft. to 19 ft.

Caissons are shown in the plan in Fig. 1. They were all 7 ft. 4 in. wide and varied in length from 16 ft. 9 in. to 28 ft. 11 in. Their sides were formed of 2-in. timber sheeting, which sank with the caisson. The working chambers were built of concrete reinforced with steel, the concrete being added in sections as the sinking progressed. The weight of the caissons was not sufficient to overcome the uplift in the air pressure and the friction on their sides so it was necessary to add from 300 to 600 tons of cast-iron blocks to each caisson to carry it down to bearing on the rock bottom. The caisson in the immediate foreground on the right in Fig. 2 is loaded in this fashion. The maximum air pressure used was 20½

hold the caisson in place against the pressure of the street and surrounding buildings. The layout of this cross-bracing is shown in detail in Fig. 1 and in the view in Fig. 3. The excavation was made by clam-shell buckets acting from four stiff-leg derricks. After the entire excavation was made the interior piers were excavated in the open, the hardpan being sufficiently rigid to permit of its being excavated without sheathing. These piers had only to be excavated an average depth of 9 ft. They were in general about 4x4 ft. square.

Practically the entire plant used during the excavation work is shown in the view in Fig. 2. For placing the concrete in the caisson a system of chuting the concrete was used. A tower, shown in the view in Fig. 2, was erected near the center of the lot and the concrete mixed

at the base of the tower and hoisted up to the charging hopper where it was dumped into chutes leading to the various caissons. A four-boom steel traveler derrick was erected in the west end of the lot, but only three booms were used for handling the buckets to and from the air lock. Where convenient the concrete chutes were fas-

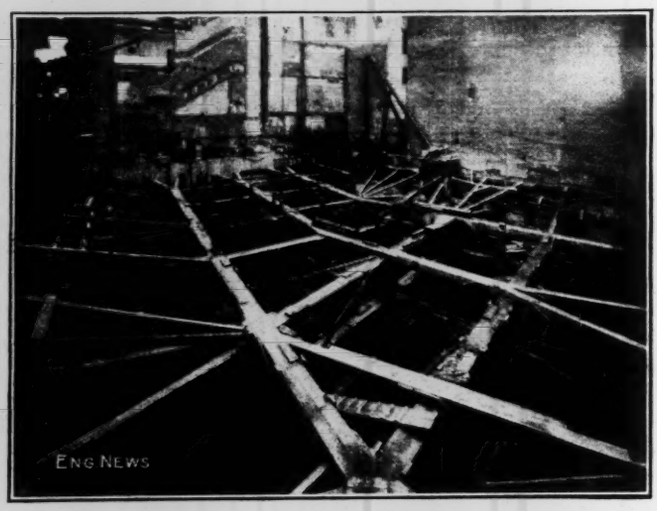


FIG. 3. CAISSON INTERBRACING, MORGAN BLDG.

tened to the sides of the steel traveler. In addition to this, two stiff-leg derricks were used at the east end of the lot.

Two wooden hoppers were erected, one on Wall St. and the other (shown at the right in Fig. 2) on Broad St. Into these hoppers the soil excavated from the caissons was dumped and from there was dumped into trucks standing in the street below. A timber platform was constructed through the center of the lot leading to Wall St. (on the left in Fig. 2). Two additional wood hoppers were built on this platform to hold the soil excavated. Trap doors were cut in the platform and all sand, stone and cement received were dumped into the bin, which emptied below into the concrete mixer. The concrete mixer and the engine for the lifting device of the tower were placed under the platform. The booms in the steel traveler with the two stiff-leg derricks touched every point of the lot, so that it was not necessary to shift the derricks at any time while the caissons were being sunk.

A hospital air lock, which is required by law, was fitted up on Wall St. to take care of any case of the bends which might occur. No workmen, however, were afflicted with the bends during the course of construction. The air lock, a circular tank, is shown on Wall St. to the left in Fig. 2.

The foundation work described above, including the underpinning of the adjacent building, was done by the Foundation Company, 115 Broadway, New York City, under the personal direction of Louis L. Brown, Vice-President of the company. Messrs. Trowbridge and Livingston are the architects, and Daniel E. Moran is the consulting engineer for the owners.

An English Hydro-Electric Plant Working under 1 to 9 ft. Head

An interesting power development for an unusual range of very low heads has recently been completed at Chester, Eng., on the River Dee. This work was recently described in the leading English papers, notably "The Engineer" (Oct. 17) and "The Electrician" (Oct. 17), from which the following information is taken.

At this place were once the famous old Dee corn mills, erected in the 11th century, but largely unused since 1895, when the municipality purchased the property. As shown in Fig. 1 there is an old stone weir extending diagonally across the river and from 7 to 10 ft. high, built as a barrier to the neap tides, the spring tides overtopping it. When the old mills were torn down in 1910,

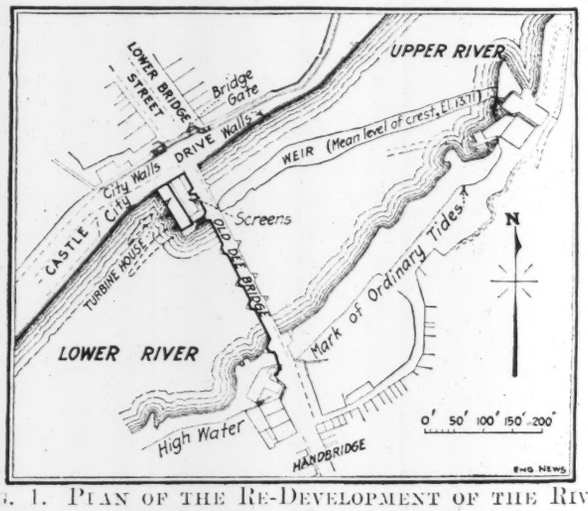


FIG. 1. PLAN OF THE RE-DEVELOPMENT OF THE RIVER DEE AT CHESTER, ENGLAND

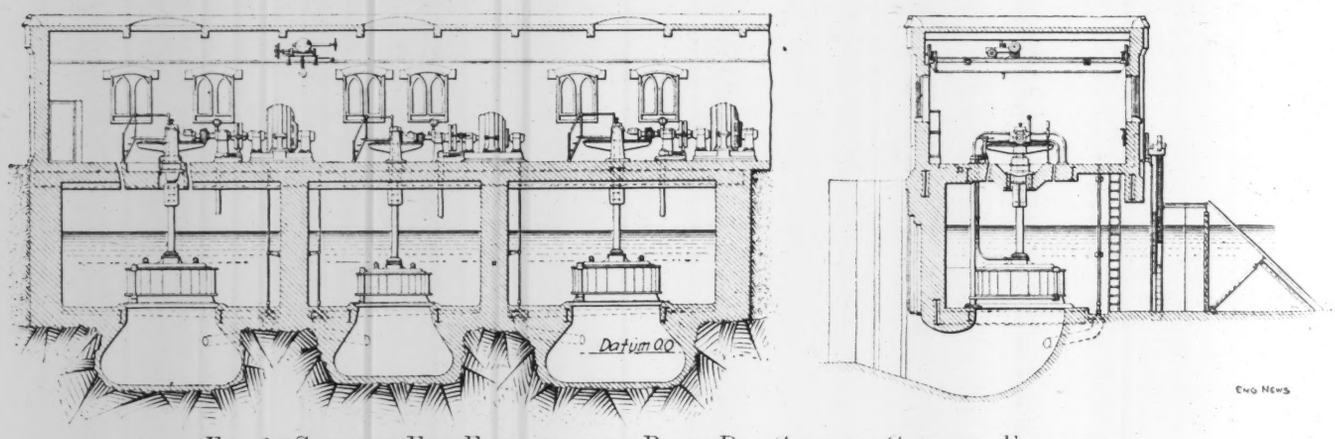


FIG. 2. SIDE AND END ELEVATIONS OF RIVER DEE STATION, CHESTER, ENGLAND

exposure of the ancient wheels revived public interest in a project to develop this power in a more modern way, and the project was finally approved.

The new station stands on the site of the old mills

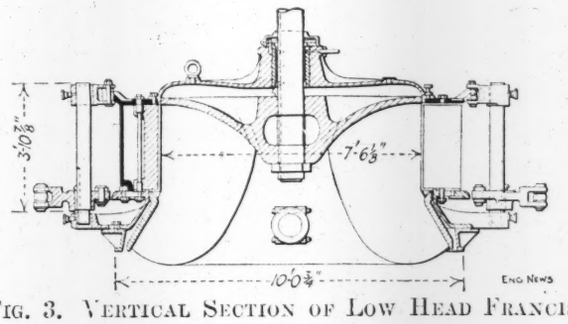


FIG. 3. VERTICAL SECTION OF LOW HEAD FRANCIS TURBINE

and it has been treated architecturally to conform to the ancient bridge of which it really is part. The retaining walls had to be reconstructed and the bridge restored as the foundations and piers were in poor shape. The station structure is of reinforced concrete, but the walls are faced on the exterior with sandstone, from the old mill foundations, and on the interior with glazed brick. The building is 84x24½ ft. and 36 ft. high from the bottom of the trail race. The generator room is lighted by three glass domes in the roof.

On account of the tidal backwater, it was necessary to use turbines and generators specially designed to work efficiently over a wide speed range. The flow in the river varies from 5000 sec.-ft. in December to 167 sec.-ft. minimum in dry weather.

As may be seen from Fig. 2, there are three vertical-shaft Francis turbines designed for working heads of from 1 to 9 ft. Two will pass a maximum of 500 sec.-ft. of water each at 9-ft. head, developing 415 b.hp. at 50 r.p.m., while the third develops 305 b.hp. at 55 r.p.m., with 367 sec.-ft. Under 1-ft. head the larger turbines at full gate pass 167 sec.-ft., developing 15.3 b.hp. at 16.5 r.p.m.; the smaller machine under 1-ft. head draws 123 sec.-ft. and develops 11.4 b.hp. at 18.6 r.p.m.

A section through one of the larger turbines is shown in Fig. 3. The motion of each runner is conveyed by gearing to a horizontal-shaft generator. The runner has forged-steel buckets cast in an iron center boss and ring. A heavy cast-iron foundation plate is machined to receive the lower plate of the guide casing, and is let into the concrete of the draft tube. The lower casing plate ring is secured to the foundation plate; the upper plate is a domed cover connected to the lower ring by heavy steel columns. The guide vanes are carried on steel spindles, and are machined top and bottom to fit the casing plates closely. The closing edges of the guide vanes are ground to insure watertightness when closed. The neck bearing of the runner shaft in the upper casing plate has a babbitted bush with cover to exclude mud, etc.; lubricating small pipes extend to the lubrication system on the generator floor. The turbine runner is supported by a suspension bearing (Fig. 4) on a massive cast-iron bridge tree. This bearing is submerged in oil, which is circulated by the bearing itself.

Power is transmitted from vertical to horizontal shafts by machine-cut helical bevel gears having a 5:1 ratio. The bridge tree for the vertical shaft support also carries one bearing of a short horizontal shaft, which, in turn, is connected to the generator shaft by a flexible joint of the pin-and-rope type.

The generators are a shunt-wound interpolar direct-current type, the two larger ones rated at 225 kw. for 440-500 volts and 143-285 r.p.m. The smaller one is rated at 185 kw. for 167-300 r.p.m., and the same voltage. The normal maximum speed is 300 r.p.m., but the machines are designed safely to stand 500, on account of the rise of speed when load is suddenly thrown off as by the opening of a circuit breaker. Current is conveyed through underground cables to a sub-station, where it goes through a reversible booster directly to the service lines, or to a storage battery installation, which assists in peak loads.

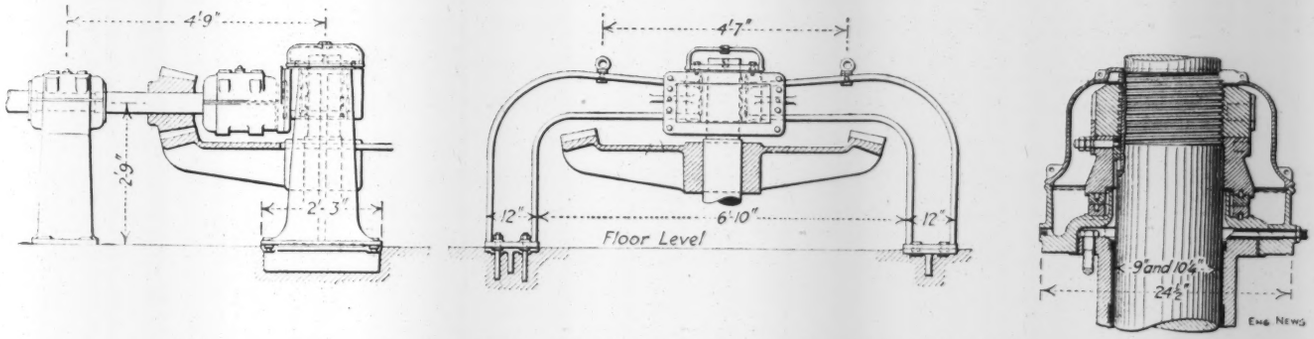


FIG. 4. BRIDGE TREE AND VERTICAL-SHAFT BEARING, DEE STATION

One unit is used with the dry-weather flow, two for average conditions, and three for wet-weather low-head flow. The annual output is expected to be some 1,250,000 kw.-hr., and the cost 0.7c. per kw.-hr., including capital charges. The labor cost is low, three men working in 8-hr. shifts.

Typhoid Fever in the United States Army has declined materially since the beginning of immunization in 1909. The record by years follows: 173 cases with 15 deaths in 1909; 143 cases with 10 deaths in 1910; 44 cases with 6 deaths in 1911; 18 cases with 3 deaths in 1912. These figures apply to officers and enlisted men located in the United States and include paratyphoid as well as typhoid. Most of the 18 soldiers who suffered from typhoid in 1912 had not been immunized and of those who had been immunized none died. The 1912 case rate was 0.29 and the death rate was 0.0475 per 1000 men. During the first six months of 1913 (so far as known up to Aug. 1) not a single case of typhoid fever occurred in the United States Army, either at home or in our outside possessions. The foregoing information has been taken from the report of the Surgeon General, U. S. Army, for 1912-13 (typhoid statistics for the calendar year 1912.) It is significant because of the applicability and occasional practice of typhoid immunization of men in engineering and construction camps.

The Hydraulic Laboratory at Syracuse University

By Paul C. Nugent*

The hydraulic laboratory of the L. C. Smith College of Applied Science, Syracuse University, is installed in Machinery Hall. This building, as well as the main building of the College of Applied Science, was the gift of the late L. C. Smith. The hydraulic laboratory proper was further donated by him, and completed, after his death, by Mrs. Smith.

The interior apparatus covers a space on the ground floor of Machinery Hall of 92x50 ft. The ceiling height is 16½ ft., giving ample space for the installation of the overhead piping, elevated flume and galleries, etc., to be described later, while the open flume, in which is now placed a mixed flow turbine, extends through to the second floor. It is planned further to extend the installation of the third floor, thus giving an opportunity for experimentation with impulse wheels discharging into a draft tube.

The water-supply is contained in the outside reservoir, 30 ft. wide and 120 ft. long, shown in the view Fig. 1 and in the plan Fig. 2. This reservoir has a capacity of about 20,000 cu.ft. The double row of concrete piers shown in Fig. 1 are supports for a future track for the testing of current meters and models of boats. The additional piers at the side of the track supports will carry a platform for the observers in these experiments.

Referring to the general plan Fig. 2, it will be noted that an elevated steel flume extends along the west side of the laboratory. This flume, constructed by the Syracuse Bridge Co., has its bottom at an elevation of 6½ ft. above the floor. Its width is 4½ ft. and its depth 3¼ ft. On it are mounted a 10-in. Pelton wheel and a 14-in. wheel of the Girard type, located as shown in Fig. 2. The Girard wheel was built by the Platt Iron Works and is a duplicate of a wheel in actual service at the plant of the Ouiatchouan Pulp Co. It is designed to operate at 1000 r.p.m. under a head of 220 ft. Near the north end of the steel flume is placed a vertical open concrete wheel pit with interior dimensions 4 ft. 6 in.x5 ft. 10 in.x10 ft. It is supported on four concrete columns, which clear the sides of the steel flume, and discharges, through a draft tube, into it. In this wheel pit, which, as stated above, extends through to the second floor, is installed a 10-in. mixed-flow turbine from the Dayton Globe Iron Works. This wheel is provided with interchangeable gates of the cylinder and wicket types. The arrangement is such that it can be conveniently lifted out for the purpose either of changing the gates or of installing different types of wheels. At the top of the pit is placed a Woodward governor designed to work with either the cylinder or the wicket gate of the Dayton wheel. Another governor, of the Lombard type, also forms part of the equipment and is located on the ground floor.

A large opening, closed by a removable wooden cover, in the concrete second floor, and situated just south of the wheel pit, gives an opportunity for lifting machinery from the ground floor and also offers a means of communication between observers at the two levels.

The steel flume is provided with walks at each side. Near its south end baffle boards are placed, and at the extreme south end is a weir. Provision is made for changing the weir plates as may be desired from time to time.

The water passing over this weir falls into the central chamber of the large concrete measuring tanks. Gates connect this central chamber with the two larger ones. The water can thus be diverted to either large tank, one being drained as the other fills, giving a continuous measurement over any desired length of time. Two other large gates, shown in Fig. 3, connect with the main sump, from which the water finally passes, through the drain pipe, back into the reservoir. The gates of the measuring chambers were furnished by the Ludlow Valve Co. The bottom of the three measuring tanks is at the level of the laboratory floor, and near the northeast corner of the left-hand large tank, is placed a cabinet containing water gages. These connect with both large tanks. It is planned to calibrate the tanks by weighing the water discharged into them and marking on a board, directly behind the gage glasses in the cabinet, the quantities corresponding to the different depths. With this arrangement, at any stage of an experiment, the quantities can be read off at once.

The two large tanks are covered in part by a concrete slab at the level of the bottom of the steel flume. The gates controlling their discharge are operated from this slab. It also supports a flush tank, the siphons of which are the product of the Pacific Flush Tank Co., and a cylindrical steel orifice tank. This last is 5½ ft. in diameter and 8½ ft. high. It, as also the drum mentioned later, was constructed by Tippett & Wood, and is pro-

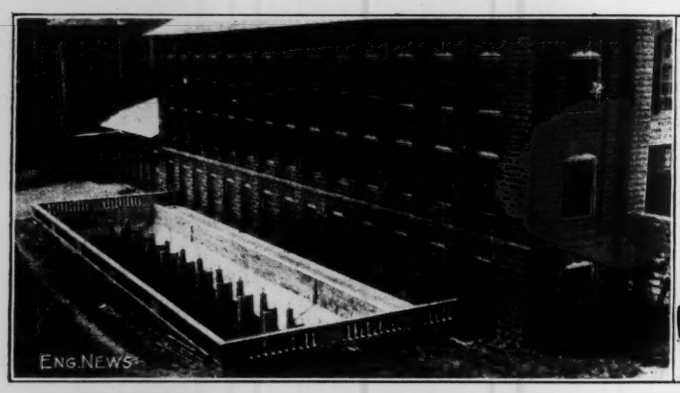


Fig. 1. View of Outside Reservoir at Hydraulic Laboratory, Syracuse University

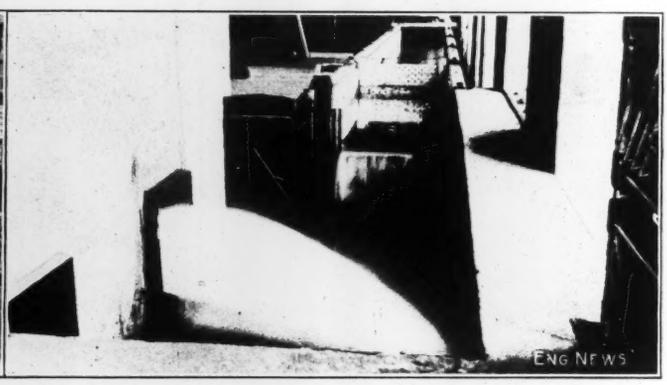


Fig. 3. View of East Flume, Weir, Main Sump, and Discharge Gates of Measuring Tanks

*Professor of Civil Engineering, Syracuse University, Syracuse, N. Y.

with apparatus, similar to that used at Lafayette College, for changing the orifice plates under pressure. It is further supplied with a water gage and attachments for pressure gages. The orifice opening faces the west end of the right-hand large tank, here not covered, and discharges directly into it.

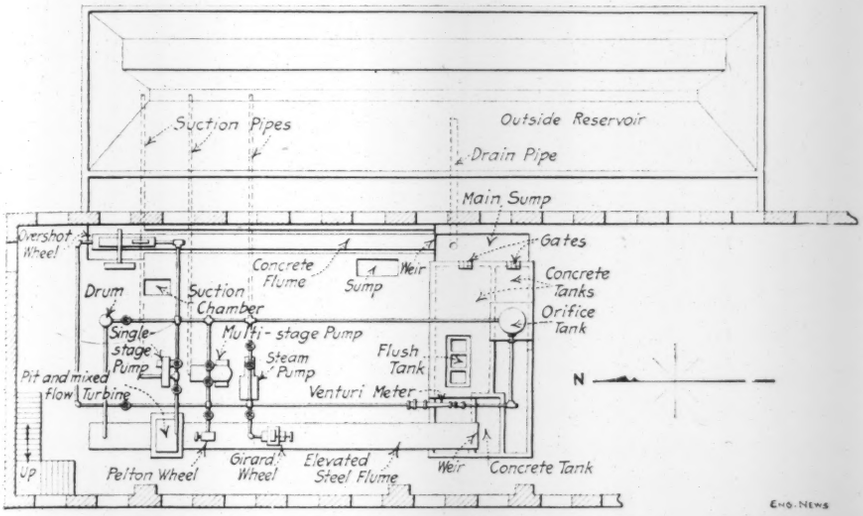


FIG. 2. GENERAL PLAN OF HYDRAULIC LABORATORY, SYRACUSE UNIVERSITY

Along the east side of the laboratory extends a second flume 3 ft. 5 in. wide and 3 ft. deep. This flume is constructed of concrete. Its bottom rests directly on the laboratory floor and at its north end, on concrete piers, is mounted an 8-ft. steel overshot wheel, manufactured by the Fitz Water Wheel Co. This wheel, shown in operation with a friction brake in Fig. 4, uses 230 cu.ft. of water per minute. The east flume is also provided with baffle boards and has at its south end a weir, Fig. 3, discharging into the main sump. It has, further, with particular reference to velocity measurements with a movable plate, arrangements for attaching a track on its top. For the purpose of determining the heads on the weirs, each of these flumes has connected to it a vertical cylindrical tank. These tanks stand on the floor and on the sidewalk east of the west flume.

For the purpose of receiving the discharge from any small apparatus which may be put into service from time to time, there has been constructed a second sump draining into the main one. A general system of floor drains leads through the two.

On the plan, Fig. 2, in addition to the drain pipe are shown four suction pipes leading from the reservoir to the laboratory. At present three of these are connected to the pumps. The fourth is a reserve pipe for use with future possible apparatus.

Of the three pumps now installed, one is a single-stage, 6-in. De Laval centrifugal, having a capacity of 300 cu. ft. per minute, under a total head of 25 ft. It is operated by a 25-hp. direct-connected Westinghouse motor of variable speed but designed to run normally at 1250 r.p.m. This pump is designed to supply ordinarily either the mixed-flow turbine or the overshot wheel, but all of the piping is connected and the discharge from any pump may be turned into any motor. An elaborate system of valves provides for this and also, when the high-pressure pumps are in operation, for shutting off the low-pressure part of the system.

Another pump is a 6-in., 5-stage centrifugal from the Morris Machine Works. Its capacity is 75 cu.ft. per minute under a total head of 325 ft. The third pump is a Deane of Holyoke duplex steam apparatus. It is designed to work under a total head of over 325 ft. and can therefore be used very conveniently with the 5-stage pump when a large quantity of water is desired for any special high-pressure experiment. This pump is 16x10½x12 in., and has a capacity of 150 cu.ft. per min. The multi-stage centrifugal is driven by a direct-connected General Electric motor of 90 hp. capacity. As with the motor driving the single-stage pump, the speed is variable but will be normally about 1000 r.p.m.

Electric power and steam are furnished from the University power plant. The switchboard controlling operation of the motors is placed under the west flume.

The piping is carried, in general, overhead near the ceiling, a system of suspended walks giving access to all valves. The discharge pipe of each

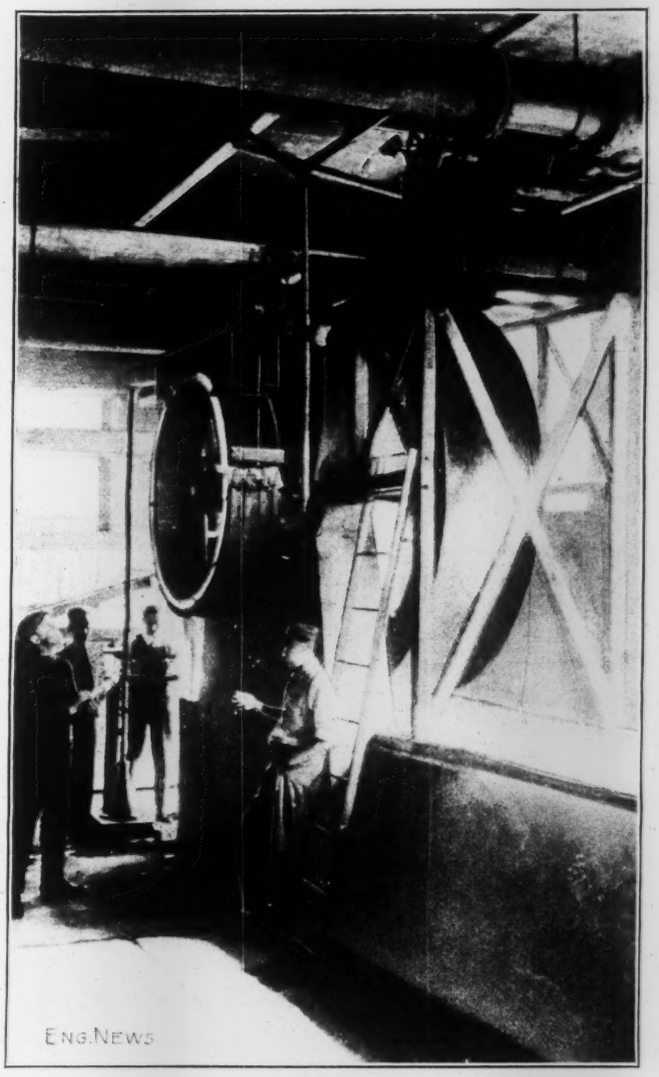


FIG. 4. OVERSHOT WHEEL IN OPERATION WITH PRONY BRAKE

pump is vertical, and at its junction with the overhead lines there are placed two valves in the main system, one on each side of the junction. Thus the water from the Deane pump, for instance, can be discharged into the Girard wheel either direct or through the pressure, or orifice tank described above. This tank may therefore be used as a large air chamber for steadying the flow.

The water passing through the orifice tank is next conducted through an 8-in. Venturi meter supplied with a manometer, both furnished by the Builders' Iron Foundry. A portable pitometer manufactured by the Pitometer Co., will be conducted to the pipe line north of the Venturi meter. Thus water passing through the pressure tank to the Girard turbine, for instance, will be measured in four ways: by the Venturi meter, the pitometer, the weir, and finally the measuring tanks. For calibrating the weir in the east flume, the water, after passing through the Venturi meter and past the pitometer, can be sent on through the pipe line to that flume and over its weir. The two weirs and the other quantity measuring apparatus are thus all interconnected and can be checked against each other.

Foot valves are provided for the suction pipes of the centrifugal pumps and they may be primed either with water from the city mains or by the use of steam ejectors.

For the purpose of obtaining the suction head, vacuum gages are attached to the suction pipes of all pumps. Or the head may be measured direct in a suction chamber. This chamber is sunk in the floor and contains water gages connected with the ends of the different suction pipes.

Experiments on friction in piping from 2 to 8 in. in diameter are provided for by a series of pipes of these sizes running in a vertical row from the orifice tank north to a vertical steel drum 3 ft. in diameter. These pipes are reached by the suspended walk giving access to the valves in the lines near the ceiling. The 2-in. pipe has been installed and is fitted with cast-iron pressure chambers at every 10 ft. of its length. It is shown in Fig. 5. The pressure chambers were made in the college foundry. They surround the pipe and have threaded openings for the attachment of pressure gages. Water is admitted by openings in the top, bottom and sides of the pipe.

In general water will be supplied from the outside reservoir by the pumps, but the piping is also connected to the city system and the pressure from that source may be thrown on by opening a valve. The external reservoir is filled through the drain pipe by opening this connection with the city system and allowing the water to run through either of the flumes. The reservoir is provided with an overflow pipe and may be drained, when desired, into the city sewers. The piping was furnished by the R. C. McClure Co., and the valves by the Fairbanks Co.

Much of the auxiliary apparatus, notably the Prony brakes and some of the pulleys on which they fit, has been made in the University shops and foundry. Other brake pulleys were furnished by the Fairbanks Co., the W. A. Jones Co., and the Dodge Mfg. Co., after specifications furnished by the Department of Civil Engineering. All of the motors, both hydraulic and electric, are provided with friction brakes. The formulas used in the design of the brake-pulley rims were the familiar one given by Flather

$$WD = PK/\pi R$$

in which W and D are the width of the rim in inches and the pulley diameter in feet respectively, while P is the power to be developed, R the revolutions per minute, and K a constant, and

$$p = 3c^2 (D/ln^2 + 0.025)$$

In this latter formula, given by Kimball and Barr, p is the maximum rim unit stress, D the mean diameter of the rim in feet, l the thickness of the rim in inches, n the number of arms in the pulley, and c the velocity of the rim in feet per second.

The use of these formulas and the conditions existing as to speeds, powers to be developed, etc., gave rise to some very interesting types of pulleys and brakes. A special rope brake frame has been constructed for use with the overshot wheel. The pulleys for testing the electric motors form part of the couplings connecting these motors with the centrifugal pumps. One of these pulleys is shown in Fig. 6. The coupling bolts are easily removable, leaving the motors free for use with the brakes.

Further apparatus are the cylindrical iron measuring tanks 2½ ft. in diameter and 4 ft. high, furnished by Mack Bros., scales by the Fairbanks Co., and the Buffalo Scale Co., a Niagara hydraulic ram, a Trident water meter, a vacuum pump and indicator outfit by the Crosby Steam Gage & Valve Co., and a Gurley current meter and hook gage. Most of the scales are made to work without loose weights. One of them is a special laboratory apparatus weighing to one fiftieth of a pound. The cylindrical weighing tanks are provided with quick opening discharge valves and are for use in experiments

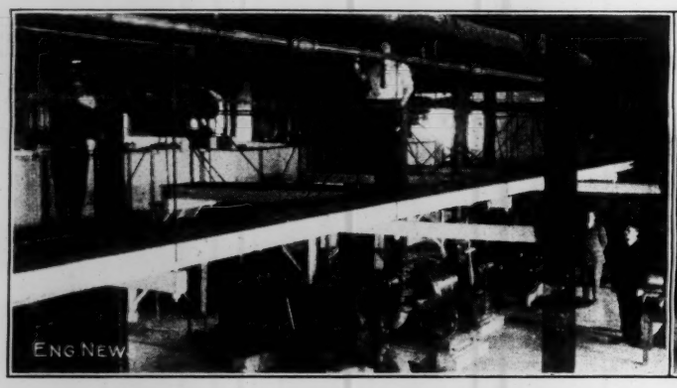


FIG. 5. VIEW OF 2-IN. FRICTION LINE AND SUSPENDED WALK

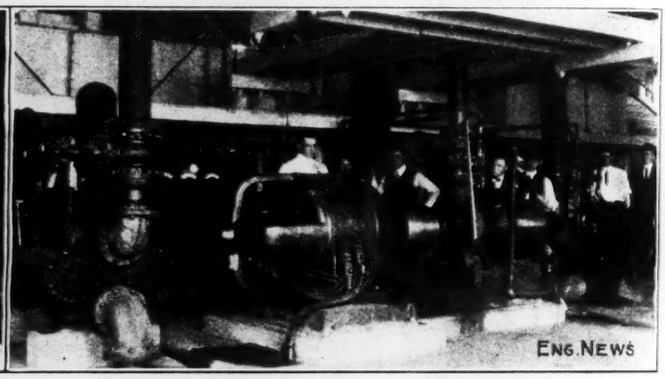


FIG. 6. COMBINATION COUPLING AND BRAKE PULLEY FOR ELECTRIC MOTOR AND MULTI-STAGE PUMP

with comparatively small quantities of water and also for calibrating the larger tanks.

The equipment further comprises tachometers of the volumeter and Horn types furnished by the Weston Electrical Instrument Co., and the Industrial Instrument Co., respectively, and a complete outfit of tools.

The general operation of the laboratory was commenced during last session and will be continued during the present one. It is planned to offer full experimental courses to the students and also to undertake a certain amount of research, the arrangement of the equipment and the facilities for installing special apparatus from time to time, having been made with this last object particularly in view.

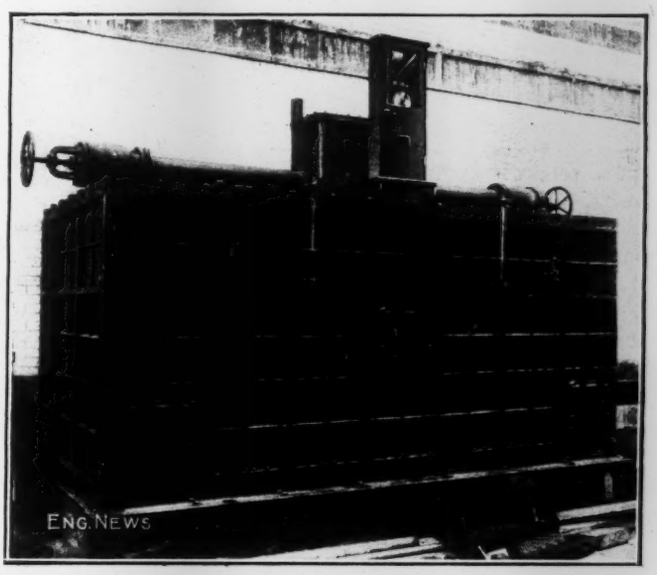
A Boiler-Feed Water Heater and Meter Combined

The metering of boiler-feed water presents certain difficulties. The water must be measured in its course between the hotwell or open heater and the boiler, and must therefore be metered while hot, perhaps at 212° F. or even higher if back pressure is carried on an exhaust steam-heating system. If water at a temperature higher than 212° F. is released to atmospheric pressure, a certain portion will be converted into steam, with a loss of heat. As water heated in an open heater under back pressure frequently has a temperature of 225-230° F., which would at once be reduced to 212° F. were the water released to atmospheric pressure, and as each 11° F. in the boiler-feed water corresponds to 1% of fuel, this consideration is a strong argument against open meters for such service, including open weirs and all meters in which the water is measured in buckets or tanks which are emptied by means of valves or siphons or by tipping. There is a further difficulty where siphons are used in that siphons will not operate with water of which the temperature approaches boiling point. This is because the water at the top of the siphon is under less than atmospheric pressure, and if less than the vapor pressure corresponding to the temperature of the water, the latter will at once form steam, breaking the siphon.

Meters which depend upon the measurement of the velocity head are employed, but when used in connection with reciprocating boiler-feed pumps, the continual variation in the rate of flow produces an illegible chart and interferes with the proper action of integrating devices.

For measuring boiling water, the open weir tank is not admissible, as explained above, and must be combined with some form of hotwell in which the water can be held under the back pressure corresponding to its temperature. This has been accomplished in the Cochrane metering heater, or combined open feed-water heater and hot-water meter, made by the Harrison Safety Boiler Works, of Philadelphia. In this apparatus the heating trays, over which the water flows through an atmosphere of exhaust steam, are inclosed within the same shell with the chamber required for the operation of a V-notch weir for measuring the flow. The sedimentation or storage chamber ordinarily included in an open feed-water heater becomes the still-water or approach chamber for the weir, and the space, cost and complication of the outfit are reduced as compared with a separate metering tank installed in connection with a feed-water heater. By venting the vapor space above the water in the metering compartment freely to the vapor space of the heater, a pressure corresponding to the temperature is maintained upon the water throughout.

A float in the outflow chamber, from which the boiler-feed pump takes its supply, controls a valve in the cold-water supply pipe, thus admitting automatically the amount of water required in addition to condensed returns from the heating system or other sources, to make up the total boiler-feed supply. The cold water is delivered into a distributing trough in the top of the heater, from which it overflows upon the usual heating trays, thence falling into a down-cast chamber and passing beneath a vertical baffle into the still-water chamber provided to insure absolute quiet and freedom from commotion in the water as it flows over the weir notch. From here the water overflows into the pump-supply chamber, the storage capacity of which is useful to absorb pulsations in the rate at which water is taken by the pumps, or at which it is delivered to the heater from steam traps, etc.



A Metering-Feed-Water Heater of 600,000 Lb. per Hour Capacity in the 201st St. Plant of the New York Edison Co.

Two very large metering heaters of this type have recently been installed in the 201st St. plant of the New York Edison Co. One of these is shown in the accompanying cut. The discharge of the condenser air pumps is first received in a metering hotwell located on the turbine-room floor, from which it is divided into equal parts, which flow to two Cochrane metering heaters on the floor below. The same hotwell also receives and divides, but does not meter, the makeup water. The hotwell has a total capacity of 1,200,000 lb. per hr., while each of the metering heaters, which are so installed that the exhaust steam supply and water are distributed equally, have a capacity of 600,000 lb. per hr. The metering hotwell measures the total steam consumption of the turbines, and by adding the readings of the metering heaters, the total boiler-feed water can be ascertained.

Cochrane metering heaters are guaranteed to give a total result, integrated over a given period of time, which will check with the weight of water used, within 1½%, under normal conditions.

Indexing and Filing Engineering Computations

By John H. Gregory*

SYNOPSIS—Describes the practice of a hydraulic and sanitary engineering office in making, indexing and filing engineering computations. Rules for the guidance of assistants are included, the necessary supplies are described, and the dealers from whom they may be obtained are given. The loose-leaf system is used, with the Dewey Decimal System for indexing purposes. The author first employed the system in 1903 when connected with the Filtration Department of the Commission on Additional Water Supply of New York City. The rules which he then prepared were subsequently rewritten and amplified by the engineering bureau of the Board of Water Supply of New York City. The system here described is based on the original and modified rules just mentioned and on the practice of the author during the past ten years.

In every engineering office computations of one kind or another have to be made. In some cases the computations are made in bound books and in others on loose-leaf sheets which may or may not be held in loose-leaf covers. For those who adhere to the method of using bound books this article will be of little interest but for those who use or desire to use a loose-leaf system it may offer some suggestions worthy of consideration.

Many computations made in connection with a given piece of work have but little value after they have served the purpose for which they were made. There are frequently some computations, however, which are of sufficient value to warrant preserving carefully for use in connection with other pieces of work. Such computations, to be of value, must be readily accessible. It is the purpose of this article to describe a system not only for indexing and filing such computations so that they can be quickly and easily referred to but also for indexing and filing those computations which have served their period of usefulness and which are preserved simply for record purposes.

The system was worked out by the writer for use in the office of the firm of which he is a member and since its adoption over two years ago has given excellent satisfaction. The system will be best understood by first examining the accompanying reproduction (Fig. 1) of one of the computation sheets, then studying the rules which are observed in making and filing computations and finally reading the discussion immediately following in which the materials used are described and comments are made on the use of the system.

Rules to Be Observed in Making and Filing Computations

Computation Sheets

STANDARD-SIZE SHEETS TO BE USED—All computations must be made on the standard-size computation sheets 8½ in. wide by 11 in. high and having printed blank headings. If a sheet wider than standard is needed it is to be made by pasting to the right-hand edge of a standard-size sheet one or more similar sheets from which the printed headings have been cut off. The wide sheet is then to be folded so as to be exactly 8½ in. wide and still leave free, on the left-hand edge of the first sheet, a margin ¾ in. wide for punching and filing.

YELLOW SHEETS—The yellow computation sheets are to be used for computations, copies of which would probably never be desired or referred to in connection with some other piece of work. The light-weight yellow sheets are to be used for miscellaneous detail work and the heavy-weight yellow sheets for preliminary summaries or where the heavier sheet would be more serviceable.

WHITE SHEETS—The white computation sheets, from which blueprint copies can be made, must be used for all summaries of data, summaries of estimates of cost, etc., and in general for all computations, copies of which are, or might be, desired.

INDIVIDUAL COMPUTATION BOOKS—Each assistant is furnished with an an Individual Computation Book, with his name marked thereon, for holding computation sheets delivered to him and on which he may be working. During the day while computations are being made or checked the sheets may, for convenience, be removed from the book, but at night all sheets containing computations must be returned to the book and fastened in. Avoid, as far as possible, having computation sheets lying around loose.

HANDLING SHEETS—Computation sheets must be handled with care at all times so as to avoid damaging them

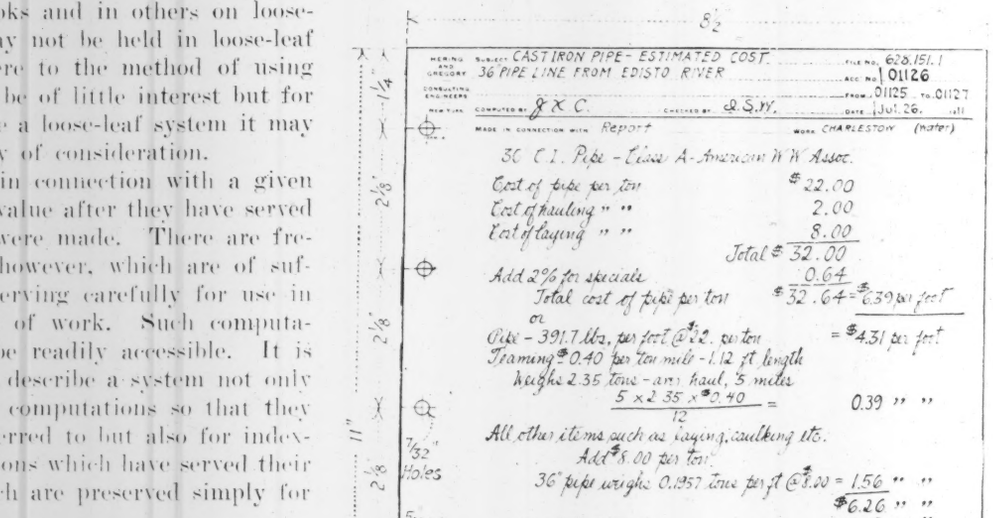

8½
HERING AND GREGORY
Subject CAST IRON PIPE- ESTIMATED COST.
File No. 628.151.1
36 PIPE LINE FROM EDISTO RIVER
Acc. No. 01126
CONSULTING ENGINEERS
From 01125 To 01127
NEW YORK
Computed by J. X. C.
Checked by C. S. W.
Date Jul. 26.
Made in connection with Report
Work CHARLESTON (water)
36" C.I. Pipe - Class A - American W.W. Assoc.
Cost of pipe per ton $22.00
Cost of hauling " " 2.00
Cost of laying " " 8.00
Total $32.00
Add 2% for specials 0.64
Total cost of pipe per ton $32.64 = $0.39 per foot
or
Pipe - 391.7 lbs. per foot @ $22. per ton = $4.31 per foot
Teaming $0.40 per ton mile - 1.12 ft length
weighs 2.35 tons - ave. haul, 3 miles
5 × 2.35 × $0.40 / 12 = 0.39 " "
All other items such as laying, caulking etc.
Add $8.00 per ton.
36" pipe weighs 0.1957 tons per ft @ $8.00 = 1.56 " "
$6.26 " "
Specials - add 2% 0.13 " "
Total $6.39 " "
Say total cost of pipe per foot - $6.40
Excavation and back fill (628.151.4 - 01122) (Rounded)
123,000 lin ft @ $0.25 $ 30,800
Pipe laid, 123,000 " " @ 6.40 787,200
Appurtenances; (628.127-01124)
23.3 miles @ $1,640 38,200
Telephone line; (628.157-01124)
23.3 miles @ $300. 7,000
Additional runs crossings 10.000
Land for pipe line; (628.157-01124)
23.3 miles @ $750. 17,500
Total estimated cost $890,700
11"
2⅛
2⅛
2⅛
2⅛
1¼
7/32" Holes
5/16

FIG. 1. COMPUTATION SHEET FOR ESTIMATING COST OF A CAST-IRON WATER-SUPPLY MAIN

When fastened in the books especial pains must be taken to turn the sheets carefully so as to prevent tearing them at the punched holes. Keep the sheets smooth and avoid turning them by means of the thumb and forefinger.

Heading Computation Sheets

Before beginning work on a computation sheet all of the blank headings at the top of the sheet, except that entitled "Checked By," should be filled in.

DECIMAL INDEX—Computations are filed in accordance with a carefully prepared list of file numbers, called the "Decimal Index to Computations." In this system of filing numbers are used to designate subjects and the nature of the computations. By this means computations of similar char-

*Of Hering & Gregory, Consulting Engineers and Sanitary Experts, 170 Broadway, New York.

ter are grouped together and are much more readily referred to than if filed alphabetically by subjects. The decimal index differs from the usual index in that it exists before the matter to be indexed is composed and thus constitutes a mold into which the matter is to be cast. In order that the index may remain a true one, however, it is necessary that it be rigidly followed even when seemingly strained. Each assistant will be furnished with a copy of the index which should be carefully studied so that computations may be made exactly in accordance with it.

FILE NO.—In the space entitled "File No." is to be inserted the file number, taken from the decimal index, corresponding to the subject to which the computations relate. If the list of file numbers seems inadequate the attention of the Office Engineer should be called to the matter at once so that the necessary additions can be made.

SUBJECT—In the space entitled "Subject" is to be inserted the classified subject corresponding to the file number, followed by a subheading and an explanatory statement, giving briefly and clearly the nature of the computations contained on the sheet.

DATE—In the space entitled "Date" is to be inserted the date on which the computations were made or begun. In writing the date the month is to be indicated by the first three letters of its name and not by a figure or figures.

ACC. NO.—In the space entitled "Acc. No." is inserted the accession number of the sheet. Two sets of accession numbers are used, one set for the yellow sheets and another set for the white sheets. The accession numbers for the yellow sheets begin with "1" and those for the white sheets with "01." In each set of sheets the accession numbers run consecutively beginning with the numbers "1" and "01" just stated. Thus the accession numbers for the yellow sheets are 1, 2, 3, 4, etc., and those for the white sheets 01, 02, 03, 04, etc. It should be noted that the first figure of the accession number on each white sheet is 0. Accession numbers are never duplicated. Computation sheets must not be used unless the accession numbers have been markd thereon.

WORK—In the space entitled "Work" is to be inserted the name of the work to which the computations on the sheet relate. In general, work will be designated by the name of the place in which the same is located. In this same space, immediately following the name of the work, is to be inserted, in a parenthesis, one or more explanatory words to indicate briefly the character of the work, as for example, Water, Sewage or Refuse. If, however, the computations are made in the course of general office work the words "Office Work" only are to be inserted.

MADE IN CONNECTION WITH—In the space entitled "Made in Connection With" are to be inserted one or more explanatory words to indicate the relation which the computations bear to the work in question, as, for example, Report, Drawings, Specifications, Etc. If the computations are made in the course of general office work the space is to be left blank or such word or words inserted as the Office Engineer will designate.

COMPUTED BY—In the space entitled "Computed By" are to be inserted the initials of the person making the computations, the initials to be written by the person himself.

CHECKED BY—In the space entitled "Checked By" are to be inserted the initials of the person checking the computations, the initials to be written by the person himself.

FROM AND TO—If only one sheet is required to complete the computations on a given subject the spaces entitled "From" and "To" are to be left blank. If more than one sheet is required the space entitled "From" on the first sheet is to be left blank, but in the space entitled "To" is to be inserted the accession number of the sheet on which the computations are continued. On the second sheet, in the space entitled "From," is to be inserted the accession number of the sheet from which the computations were continued. If the computations are completed on the second sheet the space entitled "To" on this sheet is to be left blank. If an additional sheet or sheets are needed the spaces entitled respectively "To" and "From" are to be filled in, as above described, until the set of sheets is completed.

It should be noted that on the first sheet of a series of sheets required to complete a given computation the space entitled "From" is to be left blank, while on the last sheet of the series the space entitled "To" is to be left blank. It is of especial importance that the spaces entitled "From" and "To" should be properly filled in so that, in case the sheets become disarranged, they can be quickly and easily rearranged in proper order.

WRITTEN AND LETTERED HEADINGS—On the yellow sheets all blank headings are to be filled in by writing. On the white sheets all blank headngs, except those entitled "Computed By" and "Checked By," are to be filled in with vertical lettering, with capitals or with capitals and small letters as indicated below:

Heading	Capitals	Capitals and Small Letters
Subject	MAIN SUBJECT	Sub-Heading and Explanatory Statement
Date		Name of Month
Work	NAME OF WORK	Explanatory Word or Words
Made in Connection With		Explanatory Word or Words

MAKING COMPUTATIONS

COMPUTATIONS TO BE MADE WITH INK.—All original computations must be made with Waterman's Jet Black Ink. Do not use a blotter on fresh ink; allow the ink to dry so that it will become as dark as possible. Assistants are expected to provide themselves with fountain pens for use in making computations.

MARGIN—A margin, $\frac{3}{4}$ in. wide, on the left-hand edge of each sheet must be left blank.

ONE SIDE ONLY OF SHEET TO BE USED—Computations must be made on one side of the sheet only.

INDIVIDUAL COMPUTATIONS—When, as is often the case, a number of computations of various kinds are necessary in order to solve a comprehensive problem the individual computations should be general in their application and elementary as far as possible so that the individual computations may be useful in solving other problems. The individual computations should, as far as the general scheme of making computations will allow, be made on separate sheets and the results only collected and used in solving the specific problem in hand.

EXPLANATORY NOTES—Sufficient explanatory notes should be inserted to make each computation perfectly clear and whenever data are taken from another sheet its file number and accession number should be given. The file number and accession number of the sheet referred to should preferably be expressed in the form of a fraction with the file number as the numerator and the accession number as the denominator and the whole inclosed in a ring, as, for example, $\frac{628.16}{0321}$. If space will not permit of thus expressing the file and accession numbers they should be inclosed in brackets with a dash between the file number and the accession number, thus, [628.16—0321]. A summary of the principal results of a computation should be made when it is evident that such a summary would be convenient for reference. If a drawing is used in connection with a computation, or if a reference to one is desirable, the number of the drawing should be given.

ACCURACY—Be accurate, systematic and neat. Do not waste time on unnecessary refinement. Do not use more decimals than the accuracy of the data warrants or th enecessities of the result make advisable.

COMPUTING—Use slide-rules, computing machines, logarithms and diagrams whenever their use will economize time and secure sufficient accuracy. Assistants are expected to provide themselves with small slide-rules, but more expensive computing devices will be furnished whenever adequate economy will result.

CHECKING—Checking, especially of important computations, must be done independently. Simply going over the figures made by another is not checking. Errors in data, methods, deductions or judgment must be detected, as well as errors in mathematics.

TABULAR FORM—Make it a rule to use a tabular form for computations whenever possible. A little preliminary thought will usually show a suitable method of tabulation. By using a tabular form the computations will be made quicker, will probably be more correct and will be much easier to refer to, as well as enabling additions to be made to widen the scope of the results. Mathematical work which can be done by slide-rule or computing machine should be left off the sheets as the tabulation will indicate the process followed.

BREVITY—Be brief. Use judiciously abbreviations which are sufficiently self-evident. Do not repeat unnecessarily. Do not waste time stating matters of common knowledge such as the value of π and what it means, or deductions of formulas which can be readily found in text-books.

ERRORS—If an error is made on one of the white computation sheets and is discovered by the person making the same before the sheet has been turned over to another person to be checked it should be rectified by using an ink eradicator if it is possible to do so without damaging the sheet or without expending a great amount of time in making the correction. If the error is made on a yellow sheet the ink eradicator may be used if by its use a saving in time will result. If, however, the error is found when the sheet is being checked, or at a later date, the original figures must not be erased or removed with an ink eradicator, but the correction made with Waterman's red ink and the office engineer

notified at once so that the mistake can be rectified in all places affected.

SUPERSEDED SHEETS—Under no condition is a computation sheet to be destroyed. If, for any reason, a sheet becomes useless the prefix "X," meaning superseded, is to be inserted in front of the file number on the sheet and the word "SUPERSEDED" then stamped in red across the face of the sheet.

SHEETS TO BE TURNED IN—In general, at the end of each week, and more frequently if circumstances warrant, computation sheets which have been completed and checked, as well as superseded sheets, are to be turned into the Office Engineer for filing.

FILING OF COMPUTATION SHEETS

FILING OF SHEETS—All computation sheets will be filed under the direction of the Office Engineer.

CURRENT COMPUTATION BOOKS—Computation sheets, as soon as turned in, are filed temporarily, until the completion of the work to which they relate, in the Current Computation Books. In these books the sheets are to be filed alphabetically under the names of the work to which they relate with the sheets arranged numerically thereunder by file numbers.

TRANSFER OF SHEETS FROM CURRENT COMPUTATION BOOKS—When a piece of work has been completed and all of the computation sheets relating to the same have been turned in they are transferred from the Current Computation Books, the yellow sheets to the Closed Data File and the white sheets to the Reference Data Books in which they are filed permanently. Before transferring these sheets from the Current Computation Books, however, the File Number and Accession Number of each white computation sheet must be listed on a sheet of plain white paper of the same size as, and punched to correspond with, the standard computation sheets, the sheet being headed with the name of the work and with the words "Computation Sheets Transferred to Reference Data Books." This sheet must then be transferred with the yellow computation sheets to the Closed Data File so that, should it be necessary at a later date to refer to the computations in the Closed Data File, reference can also be made to the white computation sheets transferred to the Reference Data Books.

CLOSED DATA FILE—The yellow computation sheets relating to each piece of work, when removed from the Current Computation Books, together with the white sheet giving the file and accession numbers of the white computation sheets transferred to the Reference Data Books, are filed permanently in the Closed Data File. The sheets must be arranged numerically by file numbers, must be bound firmly together with McGill fasteners and are then to be placed in a 9x12-in. envelope. The envelope is to be marked with the name of the work and with the year or years in which the work was done, the marking to be so located that it will be in the upper left-hand corner when the envelope is filed in the Closed Data File. The envelope is to be filed alphabetically under the name of the work to which the computations held therein relate. If more than one envelope is needed for a given piece of work each envelope is to be marked as described above and also with two file numbers giving the limits between which sheets are filed therein.

SUPERSEDED SHEETS—Superseded sheets, both yellow and white, are also filed in the Closed Data File in an envelope marked "Superseded Sheets." The sheets are to be fastened together and are to be arranged numerically by file numbers with the sheets arranged thereunder in accordance with the dates.

REFERENCE DATA BOOKS—The white computation sheets removed from the Current Computation Books are filed permanently in the Reference Data Books. Each sheet is to be filed first, numerically by its file number, second, alphabetically thereunder by the subject if more than two subjects have the same file number, and third, alphabetically under the name of the work to which the sheet relates. For convenience of reference a copy of the Decimal Index is filed in the front of each Reference Data Book.

REMOVAL OF FILED SHEETS—Computation sheets which have been filed in either the Closed Data File or the Reference Data Books must not be removed except under such regulations as the Office Engineer shall find suitable in each case.

Materials Used in Carrying Out the System

SIZE OF SHEETS—Sheets 8½ in. wide by 11 in. high were adopted not only for the reason that the size is a convenient one but also for the reason that this size has been almost universally adopted for business letter paper. When it is desired to send away copies of estimates or data contained on the white computation sheets, blueprints or whiteprints of the computation sheets are taken and such prints, when accompanying a letter, present a neater appearance than if of a size different from that of the letter paper. Further, most papers will cut to the 8½x11-in. size without waste.

YELLOW SHEETS—Two kinds of yellow computation sheets are used, one a light-weight paper and the other a heavy paper. For the light-weight sheets a good quality smooth yellow block paper is used, the printed heading at the top of the sheets being put on in the office with a rubber stamp using a quick-drying black ink. The sheets come with the ordinary standard horizontal ruling and without a vertical margin line on the left-hand side.

As the light-weight yellow sheets are the ones used most extensively it has been found desirable to have them blocked to order with the sheets held simply at the bottom. This method of blocking has several advantages. One is that the printed headings at the top of the sheet can be more readily stamped on than if the sheets are held at the top. Another advantage is that the sheets have clean-cut edges, when removed from the block, not only at the top and on the right-hand edge but also on the left-hand edge along which the holes are punched, as there is less liability for the hand or arm to damage the sheets while working on them if they are held at the bottom instead of being free. The additional cost of having the sheets thus blocked is slight.

For the heavy sheets 24-lb. buff National Bank Linen Ledger paper is used. The heavy sheets are quadrille ruled and the headings at the top are printed. The heavy sheets are not blocked.

WHITE SHEETS—Any first-class medium-weight white paper will serve if the surface is such as to take ink well. After trying a number of papers it has been found that excellent results are secured with 16-lb. plain bond paper, Minerva No. 1722, manufactured by H. Lindenmeyr & Sons, New York. This paper has no watermark, has sufficient body and strength, will stand the use of an ink eradicator and still is thin enough so that excellent blueprints can be obtained from it. A paper with a watermark can, of course, be used but one without a watermark is preferable as blueprints taken from such paper are not only easier to read but present a better appearance.

Two kinds of white sheets are used, one quadrille-ruled similar to the heavy yellow sheets and the other plain. Both kinds of sheets, have, however, the standard printed heading. The quadrille-ruled sheets are those most frequently used of the white sheets for computations but occasionally a plain sheet is desired. The white sheets are not blocked.

From time to time data of much value are received or come to notice in one way or another and it is often more convenient to have such data immediately at hand than to have to look them up in letter files, books or back numbers of the engineering papers, when wanted. When this is the case such data are copied with a typewriter on the white computation sheets. Strictly speaking, such data are not computations but are of sufficient value to warrant filing in the Reference Data Books.

QUADRILLE RULING—On the white sheets and on the heavy yellow sheets which have quadrille ruling the lines are spaced five to the inch, both vertically and horizon-

ally, with every fifth line heavy. The ruling is done with a light-blue ink, and one which is not attacked by an ink eradicator is preferable. Black and orange-colored inks have also been tried but the light-blue ink has been found to be the most satisfactory. The light-blue ruling is much easier on the eyes than black or orange ruling and gives but faint white lines on blueprints taken from sheets thus ruled, a feature generally desired. In some cases, of course, it would be desirable to have the ruling somewhat prominent and give good white lines on the blueprint but in by far the greatest number of cases it is desirable not to have the ruling prominent or to give more than faint white lines on the blueprint.

PUNCHING—All computation sheets, both yellow and white, are punched with five holes in the left-hand margin, the spacing being that shown in the accompanying cut. Sheets punched with the spacing shown will fit not only the three rings in the I. P. Binder but also the five posts in the Moore Binder, used respectively for the Computation Books and for the Reference Data Books.

The sheets are punched in the office as it has been found difficult to always secure accurate work otherwise. It is essential, especially for filing the white sheets in the Reference Data Books, that the sheets be punched accurately. The white sheets and the heavy yellow sheets are punched as soon as they are received at the office and the light-weight yellow sheets after they have been used and removed from the blocks.

Several punches are on the market but of the less expensive ones that which has been found to serve the purpose well and to punch all five holes at one time is the Ambart punch, made by the Barrett Bindery Co., Chicago. This punch, as ordinarily furnished, is adjustable to a certain extent but the adjustments are not such as to punch the five holes to fit the I. P. and Moore Binders. At a slight additional cost, however, the punch can be arranged so as to punch the five holes at the spacing desired and at the proper location on the sheet. Much time and annoyance will be saved by securing a good punch that will do the work accurately.

ACCESSION NUMBERS—The accession numbers are stamped on both the yellow and white sheets with a numbering machine, using black ink. The work is all done by one assistant whose duty it is to keep on hand a stock of computation sheets, both yellow and white, with the accession numbers marked thereon. This has been found necessary in order to prevent the duplication of accession numbers and uncertainty as to the next consecutive accession number.

INK—All work on the computation sheets is done with ink. On the yellow sheets, from which blueprints are not desired, any good ink, suiting the taste of the person using the same, can, of course, be used. On the white sheets, however, if blueprints are to be obtained from them, it is necessary to use a good quality of black ink which will give white lines when blueprints are taken from the sheets. Most of the ordinary writing inks on the market will not give satisfactory results. Of those which will, among the best is Waterman's Jet Black Ink, made by L. E. Waterman & Co., New York. In addition to giving white lines on a blueprint the ink flows well in a fountain pen and also can be removed by an ink eradicator, a feature which is of value if it is desired to keep the computation sheets as neat as possible.

COMPUTATION BOOKS—For the Individual Computation Books and Current Computation Books in which the sheets are held until they are permanently filed either in the Reference Data Books or in the Closed Data File, the No. 701 canvas-covered I. P. Ring Binders for holding 8½x11-in. sheets, made by the Irving Pitt Manufacturing Co., Kansas City, Mo., are used. These binders have three rings for holding the sheets, are quickly opened and closed, and have been found to give the best service for the temporary holding and filing of sheets.

Each Individual Computation Book is so marked on the back, and in addition is added, on a label, the name of the person to whom the book has been assigned.

Each Current Computation Book is also marked on the back, and on the label are given the names of the pieces of work, relating to which computation sheets are to be filed therein. Blank sheets carrying index tabs with the names of the different pieces of work marked thereon are inserted in these books to facilitate the temporary filing of and reference to the computation sheets.

Where a large number of computation sheets are used in connection with a certain piece of work one of the Current Computation Books is given up solely to this particular piece of work, the book being so marked on the back, and it often happens that more than one Current Computation Book is needed to hold all of the sheets.

As the Current Computation Books are used over and over again for different pieces of work it is obvious that the labels on the backs of the books, designating the temporary filing places for current computation sheets, must have additions made to them as new pieces of work come up or must be replaced with new labels. The time required, however, to keep the labels uptodate or to replace them with new labels is negligible.

REFERENCE DATA BOOKS—For the Reference Data Books, in which the white sheets are filed permanently, Moore Loose-Leaf Binders, No. 179,679, made by the John C. Moore Corporation, Rochester, N. Y., are used. These binders, which are of special size and which are made to hold 8½x11-in. sheets, are 3 in. thick and are made up with cloth sides and leather backs and corners. On the back of each binder is lettered, with reasonably large letters, the words "Reference Data Book." Immediately below the lettering a label is added on which two file numbers are marked giving the limits between which sheets are to be filed in that book.

The Moore binders are fitted with five posts for holding the sheets. The two outer posts and the middle post are fixed firmly to the rear cover of the binder, while the other two posts are attached to a removable cross-bar. The three fixed posts are spaced to correspond exactly with the spacing of the three rings of the No. 701 I. P. Binder so that the sheets will be interchangeable between the two sets of binders.

In order to file a sheet in its proper location in one of the Reference Data Books it is necessary to remove the cross-bar, holding the two fixed posts, together with all the sheets beginning at the front of the book and extending down to the point at which the new sheet is to be filed. In order to prevent damaging the sheets which have to be removed in order to file a new sheet, and also in order to facilitate the operation, it has been found advisable to first slip in a piece of medium-weight pressboard at the bottom of the stack of sheets which must be lifted out of the binder and to lift the sheets out with

the pressboard at the bottom. The pressboard is cut the same size as the computation sheets and has five holes slotted out to the edge on one of the long sides, the slotted holes being spaced so as to fit around the five posts. Further, the pressboard facilitates the replacing of the sheets in the binder as it gives a more or less stiff stack of sheets to handle, and also prevents the damaging of the holes in the sheets as the sheets are being replaced on the fixed posts.

Blank sheets carrying index tabs with different file numbers marked thereon are inserted in the Reference Data Books not only to facilitate the filing of, but future reference to, the computation sheets.

As the Reference Data Books fill up but gradually with computation sheets it has been found advisable to keep the books fairly well filled up by inserting sheets of paper at the back of each book. The advertising pages or covers of the engineering papers, cut to the right size and punched, serve this purpose well. These sheets are removed from time to time as occasion demands, to make room for the filing of the computation sheets.

Closed Data File—For the Closed Data File, in which the yellow sheets are permanently filed away, Vertical File Transfer Cases, No. AL6 10¼ in. high, 6 in. wide and 12¾ in. deep, outside measurements, made by the Macey-Dohme Co., New York, are used. A filing cabinet can, of course, be used but in general the transfer cases will probably be found the most satisfactory for the reason that the sheets filed in them have served their purpose and are being retained mainly for reference in case question should arise, the answers to which would have to be secured from an examination of the sheets filed away. The Closed Data File serves practically the same purpose as the transfer cases used in connection with a vertical filing system. The envelopes used for holding the computation sheets of the separate pieces of work are Dennison's Manila Clasp Envelope, No. 90, 9x12 in., made by the Dennison Manufacturing Co., New York.

Comments on the Use of the System

The loose-leaf system for computations is not new; in fact, it has been in use for many years. Different methods of indexing the sheets have been used but as far as the writer is aware the first use of both file numbers and accession numbers for indexing loose-leaf computation sheets was by the Filtration Department of the Commission on Additional Water Supply of New York City, in 1903. The writer suggested its use and at that time prepared a set of rules which were observed in making computations. Each assistant in the department was supplied with an individual computation book and all computations as soon as completed were filed in a set of books called Reference Computation Books. No attempt was made to file the more valuable computations in a separate file, in fact, for the work done there, it was better to have the sheets all in one file.

Subsequently when the Board of Water Supply of New York City was created the engineering bureau adopted the loose-leaf system for computations together with the use of both file and accession numbers for filing computation sheets. The rules used by the Filtration Department of the Commission on Additional Water Supply were rewritten and amplified and were embodied in the manual of regulations prepared for the use of assistants in that bureau. The heading on the computation sheet was also modified and improved. In the preparation of the rules given in this article the writer has made use of the old rules prepared for the Filtration Department of the Commission on Additional Water Supply, of the revised rules used by the engineering bureau of the Board of Water Supply, and of rules which the writer himself has gradually compiled during the last ten years.

The printed blank heading shown on the accompanying computation sheet (Fig. 1), is one which the writer's experience has shown to be the most useful for the class of work with which he has been connected. In making up this heading the writer combined the good points of similar sheets previously used by him with one or two desirable features from computation sheets used elsewhere and with which he was familiar. To meet the requirements of work in other offices, private or otherwise, and for special classes of work, as, for example, making current and final estimates, the heading can, no doubt, to advantage be modified, but nothing has yet come to the writer's attention to equal the combination of the file number, the accession number and the name of the work, together with provision for keeping the sheet in its proper location by means of the blank spaces entitled "From" and "To," for indexing and filing computations.

The blank spaces "From" and "To" on the sheets also afford a very convenient means of adding one or more sheets to a set of sheets which apparently has been completed. To continue the set it is only necessary to properly fill in the blank space entitled "To" on the last sheet of the set and the blank space entitled "From" on the new sheet. The new sheet must, of course, have the same file number as the other sheets. Again, it sometimes happens that it is desirable to add a sheet at the beginning of a set as, for example, a summary of the principal assumptions used in the computations. This is done similarly by properly filling in the blank spaces entitled "From" and "To" respectively, on the first sheet of the set and on the new sheet.

Of greatest importance is a proper index or list of file numbers. The success or failure of the system will depend as much on this one feature as on any other. In an office confined more or less to one special class of work a decimal index can often to advantage be made up to fit the work in hand but in a large office or in a private office, where of necessity work covers quite a wide range of subjects, the numbers of the Dewey decimal system can well be adopted. During the last ten years the writer has used the Dewey system and also decimal systems made up for special pieces of work with which he has been connected, but his experience leads him to conclude that the simplest and quickest method of making up an index is to adopt the Dewey system and use only such numbers of this system as are needed for the work in hand. While the Dewey system is by no means perfect, nevertheless, its adoption will be the means of saving a great amount of time, as much time and thought are required to make up a good index.

The original system is given in the "Decimal Classification and Relative Index," by Melvil Dewey, and published by the Library Bureau, New York. Extensions of the system have been published in two bulletins issued by the University of Illinois, Bulletin No. 9, "An Extension of the Dewey Decimal System of Classification Applied to the Engineering Industries," by L. P. Breckenridge

ridge and G. A. Goodenough, and Bulletin No. 13, "An Extension of the Dewey Decimal System of Classification Applied to Architecture and Building," by N. Clifford Ricker. The two bulletins are especially valuable to engineers and architects and can be purchased for a small sum.

The writer's practice has been to first select sufficient numbers from the Dewey system to cover only immediate requirements. Then, as occasion demands or convenience permits, these numbers are subdivided, if necessary, and additional numbers added. The file numbers, with the subjects corresponding, are typewritten on 8½x11-in. paper from which good blueprints can be obtained. The paper should not have a watermark as the prints taken

DECIMAL INDEX TO COMPUTATIONS. 628.165

File No.	Subject.
628.16	WATER PURIFICATION. (Continued)
.165	Chemical Treatment.
.165.1	Chemicals.
.165.11	Copper Sulphate.
.165.12	Hypochlorite of Lime.
.165.13	Hypochlorite of Soda.
.165.14	Sulphate of Alumina. Alum.
.165.15	Lime. Hydrated Lime.
.165.16	Sulphate of Iron.
.165.17	Soda Ash.
.165.18	Ozone.
.165.19	Other Chemicals.
.165.191	Liquid Chlorine.
.165.192	Sodium Thiosulphate.
.165.2	Chemical Devices.
.165.21	Storage Bins. Storage Hoppers.
.165.22	Conveying Apparatus. Weighing Apparatus.
.165.23	Dissolving Tanks.
.165.24	Slaking Tanks. Slaking Machinery.
.165.25	Solution Tanks. Stirring Devices.
.165.26	Chemical Piping. Steel. Wrought Iron. Cast Iron. Copper. Brass. Composition. Bronze. Lead. Lead Lined. Rubber.
.165.27	Chemical Feed Regulators.
.165.28	Grids. Application Devices.
.165.29	Other Devices.
.165.3	Sterilization. Disinfection. (See also 628.32)
.165.31	Copper Sulphate.
.165.32	Hypochlorite of Lime.
.165.33	Hypochlorite of Soda.
.165.34	Ozone.
.165.35	Lime.
.165.36	Liquid Chlorine.
.165.4	Clarification.
.165.41	Sulphate of Alumina. Alum
.165.42	Lime. Hydrated Lime.
.165.43	Lime and Iron.
.165.5	Softening.
.165.51	Lime.
.165.52	Soda Ash.
.165.53	Lime and Soda Ash.
.165.6	Hardening.
.165.7	Decarbonation. (By Aeration 628.164)
.165.8	Effect of Chemically Treated Water. (See also 628.153)

628.165

FIG. 2. DECIMAL INDEX TO COMPUTATION SHEETS

(The original sheet was 8½x11 in., leaving margins of ¾ in. on the left-hand side and ¼ in. on the top, bottom and right-hand sides which are not represented in the reproduction.)

from it are constantly referred to. One of the sheets from the Decimal Index to Computations is reproduced as Fig. 2.

In making up an index it will be found advisable not to make it too elaborate at the start. In general it is better to start with a few numbers carefully selected and to add to them from time to time than to undertake to try and make the index complete to begin with. It will sometimes be found that a subject can be classified under two or more numbers given in the Dewey system. In such cases it is well to consider carefully under which number the subject is best classified and then, after having selected the number, stick to that number regardless of the fact that it would be possible to use also another number.

A relative index in which the subjects are arranged alphabetically, with the file numbers corresponding thereto, is a convenience, especially for those not familiar with the decimal index, but hardly a necessity. One soon becomes so accustomed to the decimal index that the proper file number can be quickly found without having to refer to a subject index.

For some reasons a somewhat different set of accession numbers from those described above, beginning respectively with 1 and 01, might be more useful. For example, the accession numbers on sheets used in the year 1913 would be 131, 132, 133, 134, etc., on the yellow sheets and 0131, 0132, 0133, 0134, etc., on the white sheets. That is, the first two figures of the accession numbers on the yellow sheets and the first two figures following the 0 of the accession numbers on the white sheets are constant for any given year and indicate the year in which the computations were made. The figures following the two figures just mentioned, indicating the year, are then really the accession numbers. With the beginning of a new year two new sets of accession numbers would be begun, thus for the year 1914 the yellow sheets would bear the accession numbers 141, 142, 143, 144, etc., and the white sheets the numbers 0141, 0142, 0143, 0144, etc.

If it is desired to keep the number of figures in the accession numbers at a minimum, the figure 1 at the beginning of the accession number on each yellow sheet and also the figure 1 following the 0 of the accession number on each white sheet can be dropped. The accession numbers for the yellow sheets for the year 1913 would then be 31, 32, 33, 34, etc., and for the white sheets 031, 032, 033, 034, etc.

If either of the methods of accessioning the sheets just described is used care must be taken toward the end of the year to see that the stock of sheets stamped with the accession numbers is kept at a minimum so that at the end of the year the stamped sheets will all have been used up and none left over which would bear the wrong accession numbers for use in the next following year

It may appear to some that the system of indexing and filing computations just described is somewhat complicated. Experience, however, has demonstrated that just the opposite is the case. Computations are really made quicker and easier, time is saved, and valuable computations which are of service on more than one piece of work can be quickly referred to.

Agitation for Uniform Highway Laws—A committee of the American Highway Association composed of P. T. Colgrove, President of the Michigan Good Roads Association; A. N. Johnson, State Highway Engineer, of Illinois; J. E. Pennybacker, Executive Secretary of the American Highway Association, and A. B. Fletcher, State Highway Engineer, of California, has conferred with Frederick E. Wadhams, chairman of a special committee of the American Bar Association, and with Charles T. Terry, chairman of the standing committee of the Bar Association on uniform legislation, for the purpose of inaugurating a comprehensive program for improving the system of highway management in all the states.

Certain basic principles will be recommended for enactment into law by all the states, such as the establishment of non-partisan boards which will select all engineers in direct charge of roads with a view to removing the chief road officials from politics. It will also be recommended that the road chiefs be selected for periods determined by their usefulness, rather than any set term of years. Aside from the basic principles, the legislators of the different states will be asked to evolve from a compilation of laws, to be undertaken by the committee, such legislation as will be best adapted to the needs of their own state, with an eye to nation-wide uniformity.

Valuation of the Sewers of Manhattan Borough, New York City

By Otto Hufeland*

SYNOPSIS—The valuation of a sewer system, the construction of which was begun two hundred years ago, but most of which has been built since 1835, is here described. The system employed involved a determination of original cost from records and estimates and of depreciation by means of curves based on progressive depreciation as determined by careful examination of a considerable mileage of sewers and by the experience of the engineers and inspectors of the Bureau of Sewers. It was concluded that the physical life of a brick sewer in Manhattan Borough is about 64 years. The total cost of some 483 miles of brick, pipe and wood sewers, with manholes and catch basins, figured out as $24,880,000, and the present value as $18,665,000, giving an average depreciation of less than 22%. This valuation takes no account of obsolescence.

*

The sewer valuation here described is part of a plan, formulated by the accounting officers of the City of New York, to set up a capital balance sheet which would show the City's assets and liabilities, both bonded and otherwise, offset by its property real and personal, in the same manner as that of a railroad or industrial corporation. The value of such an accounting is not confined to this balance sheet, but is an obvious aid in budget making and in the control of the city's financial affairs.

Among the several classes of "permanent property" owned by the city, the cost of which is largely represented in the outstanding bonds are the sewers, which in such an accounting must be entered as an asset, not at their original cost, but at their present value, to determine which was the object of this work.

A committee of engineers was designated to prepare a general outline for the finding of values for the city's permanent property, but after much discussion the committee confined its recommendations, so far as they relate to sewers, to two points and merely advised: (1) that original cost be made the basis of the valuation and (2) that in fixing this cost, the cost of the pavement should be omitted or at most that only the cost of a cheap (cobblestone) pavement be included.

Such a valuation for the Borough of Manhattan (the old City of New York) was a work of considerable difficulty. Sewers and drains had existed there for more than two hundred years. As early as May, 1696, the Common Council ordered estimates for "a common sewer in Broad St." and a month later it was reported that:

> The Comitee doe find it will be in length Eleaven hundred And fifty eight foot, And doe compute that Every foot will Cost fifteen Shillings. [Probably for a stone box drain 4 ft. square.]

Sewers were built as needed without any system or order until 1865, when a law came into operation that required the filing of a proper plan for sewerage districts. These districts, however, were largely arbitrary subdivisions of the map of the old city and it was not until several years later that a serious effort was made to design sewers with any reference to the work that was expected of them.

With such an inheritance, the engineers of a later period often found difficulty in making needed extensions without rebuilding large sections, and were compelled to build sewers that would not have been included in a properly designed sewerage system. This will account for many of the apparent inconsistencies disclosed by a close study of the sewer sizes.

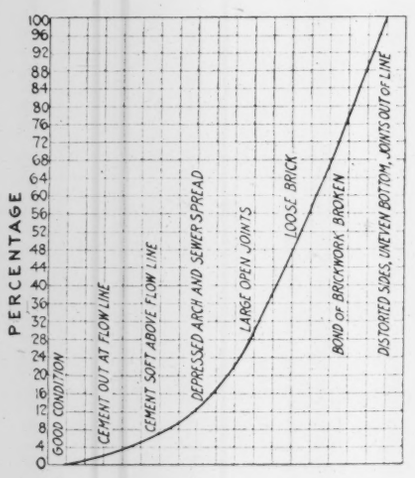


Fig. 1.

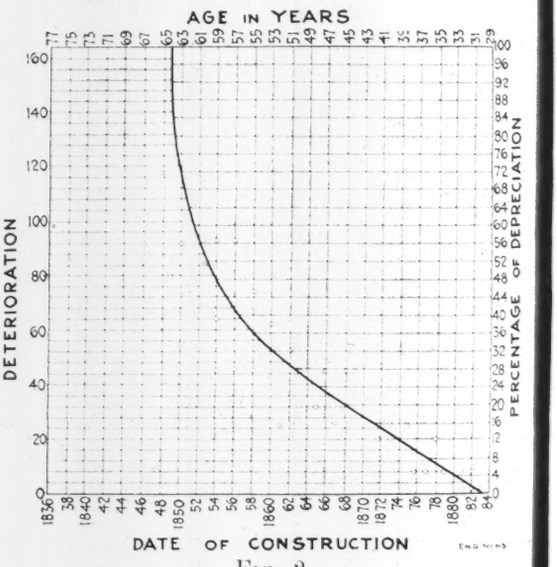


Fig. 2.

Fig. 1. Proportionate deterioration from various causes. Fig. 2. Percentage of depreciation based on examination of sewers, use of deterioration curve (Fig. 1) and age of sewers examined.

Figs. 1 and 2. Diagrams Used in Estimating Depreciation of Brick Sewers Due to Age, Manhattan Borough, New York City

To determine the cost and present value of about 500 miles of such sewers was the problem. No records existed of the cost of the earlier sewers, and it was not until the early fifties that a guide was found in old reports. Sewers first began to increase rapidly about 1835, but the prices for labor and material did not vary materially from those of the early fifties, nor were the overhead charges much different.

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The work committed to the writer was to fix the "present value" (Dec. 31, 1913) of the sewers in the Borough of Manhattan so that it could be used as one of the assets in the proposed balance sheet. For this it was necessary to find the original cost, the deterioration due to age and other causes, and the resultant depreciation.

This deterioration could, of course, have been best determined by a systematic detailed examination of the whole 500 miles, but the time allowed as well as the money available for the work made such an undertaking out of the question. It was, therefore, necessary to find a cheaper and quicker method. A search of the literature on the subject yielded no help, so that it was necessary to devise a plan that was practical under the conditions imposed and that could be defended among engineers and accountants as a consistent and trustworthy guide through a new and difficult undertaking.

The effort to fill these requirements is described in the following paragraphs, slightly modified from the final report. In outline, the method consisted in fixing steps of deterioration based on the actual examination of a sufficient mileage of sewers, finding a proportionate value for each of these steps and fixing the total deterioration by summing up the value of the steps. The total deterioration of each sewer examined was then plotted on a diagram in which the years in which the sewers were built formed evenly spaced ordinates and a curve drawn through the points so obtained indicated the average deterioration with the resultant depreciation for each and all the years on the diagram. The greater part of the text of the report, modified as stated, is as follows:

MODIFIED TEXT OF REPORT

The present value of the sewers depends, aside from the effects of age, on many factors—such as the care exercised in the original construction, the materials used, the kind and quantity of sewage carried, the care taken in maintenance and finally the injuries caused by the careless building of adjoining subsurface structures. It was assumed that the combined effect of the above was nearly uniform in the entire system, and that the total depreciation from these causes would depend on the number of years during which the sewers had been subjected to them. In other words, that next to an actual examination the age of the sewer was a fairly safe guide in fixing its present value. Accepting this view, it was necessary to formulate a rule that would admit its practical application.

The method adopted to provide the data on which such a rule could be worked out consisted in making a careful detailed inspection, by selected men, of a sufficiently large number of representative sewers of various ages, and from such inspection try to determine the slow-working effects of age, as well as the average injuries due to the causes previously enumerated. For this purpose about sixty sewers, with a total length of about twenty miles, were selected for examination. These were divided into four periods, the first including sewers built before 1845, the second between 1845 and 1855, the third 1855 to 1872, the fourth from 1872 to 1883.

Based on an intimate knowledge of the construction and of the present condition of the sewers built after 1883, it was decided to assume that as a whole these had not materially deteriorated from their original value, so that an examination of them was not necessary. There was a small number of sewers to which this generalization did not apply, and these were valued separately on their known conditions. This view of the value of these later sewers was based to a large extent on changes in methods of construction adopted after the year above mentioned.

During the progress of the examination it was found that even with the most extreme care, the reports on the condition of the pipe sewers were unreliable and unsatisfactory; about two and one-half miles of pipe were examined but it was deemed unsafe to base general values upon the results thus obtained.

BRICK SEWERS—The examination of brick sewers, due to their accessibility, yielded better results. The routine of the examination of these sewers consisted in cleaning off the brickwork with a short broom, tapping the same with a light hammer to determine solidity and testing the cement joints by scraping with a chisel. In addition, measurements of height and width were taken about every fifty feet. The bricks of the invert at and below the flow line were examined for wear. This last test yielded no result except in a single instance where a sewer about forty years old and with an exceedingly rapid flow, showed a very slight rounding of the exposed face of the brick at the joints.

A study of the reports of these examinations disclosed that the following defects were noticeable:

1. Cement partly out at water line.
2. Cement partly out above water line.
3. Depressed arch and sewer slightly spread.
4. Large open joints.
5. Loose brick.
6. Bond of brickwork broken.
7. Distorted sides, uneven bottom, joints out of line.

These seven defects show the progressive deterioration of brick sewers in the order in which they occur under the conditions existing here (and probably everywhere else). They are, of course, not sharply defined, and, passing from one step into another and coupled with the difficulty under which sewer examinations are made, cannot be determined with as much accuracy even as would be possible in an exposed structure. But a careful study of the reports of these and other examinations made under the direction of the writer, many of them in his presence, have seemed to justify the values given on the accompanying diagram, Fig. 1. In this, the seven defects have been plotted as even divisions between a good condition and a completely unserviceable one; on the ordinates drawn through these points were plotted values, determined by a careful study, in which these defects were considered largely as the deterioration due to length of service, together with the proportional value of the sewer with such defects.

For the latter there are and can be no absolute and indisputable data, and reliance must be placed on the experience and opinion of men familiar with the maintenance of the sewer system. The values on this diagram were fixed after an extended exchange of views with the engineers of the Bureau of Sewers, as well as other officials, who have had long and intimate experience both in the construction and maintenance of the sewer system.

Fig. 1 is intended to show graphically the relative deterioration beginning with sewers in good condition at 0 and running to 100, at which point the sewer is in a state of dilapidation that requires instant rebuilding. The first very slight defect is a washing out of the mortar at the flow line, a very common condition with practically no bad effect on the sewer; this was given a value of 2; the second defect, caused by a similar condition above the flow line, was fixed at 6; to the third, a slight change in shape, due oftener to a careless withdrawing of centers when the sewer was built than to actual settling down after the cement has hardened, a value of 12 was given.

The three defects above described are minor deteriorations which are common to nearly all the older sewers, and when not coupled with other conditions affect but slightly the value and usefulness of the sewer. But after this point the deteriorations are due to structural decline, and a rapid impairment of the value of the sewer follows. For that reason the next steps were rated higher until the condition of total dilapidation was reached at 100. But before this final condition occurred, the sewer had reached a deterioration so great that repairs would not have been economical. This was assumed to be at the point where the bond of the brickwork was broken and was indicated at 72. A sewer in such a condition was assumed to be worthless. The reports of the examining parties were tabulated as shown below.

In this table the value of each of the defects, as shown by Fig. 1, was noted and the sum of these was taken as showing the total deterioration of the sewer. For example a sewer with "large open joints" was rated at 45 (2+6+12+25) if all the preceding stages of deterioration were found, but if, for instance the examination disclosed no "depressed arch and sewer spread," valued at 12, the rating would be 33 (2+6+25).

Examined by	Date of construction	Location	Length in ft.	Size	Good condition 0	Cement out at flow line 2	Cement out above flow line 6	Depressed arch and sewer spread, 12	Large open joints 25	Loose brick 47	Bond of brickwork broken 72	Distorted sides and joints out of line. Uneven bottom 100	Total or average
G	1868	46th St. 2nd to Lexington Ave.	928	4′x2′8″		x	x	x	x				45
G	1869	Ave. A, 62-66 Sts.	1120	3′0″ arc		x	x	x	x				45

Of course, where "bond of brickwork broken," valued at 72, is reached, the sewer is assumed to be valueless; all the other steps preceding 72 may exist and the sewer still be worth enough to justify repairs.

To permit a more discriminating rating, the cumulative method, above described, was adopted, by which a sewer with all the faults (2 + 6 + 12 + 25 + 47 = 92) was still worth repairing, while in one with the last fault, given at 72, it was reasonable to assume that all the preceding steps existed. The 72 was therefore added to the previously found 92 and a value of 164 was reached, when the sewer was not worth repairs and therefore valueless.

Where a long sewer covering several blocks built at one period was examined, the report on each block was noted, together with its length. The values of the deterioration were multiplied by the length of the blocks, the products were added together and divided by the total length of the sewer examined. The quotient gave the average value of depreciation for the whole.

The totals or averages obtained from this tabulation were plotted on as shown by Fig. 2, p. 84, in which the years of construction were laid down as ordinates. As the limit of deterioration, as above described, was placed at 164, the left side of the diagram was divided into 164 spaces. Horizontal lines were drawn through these points intersecting the ordinates. On this network the values from the tabulation were plotted on the proper year ordinates and the curve shown on the diagram developed.

On the right of this curve the distance between zero and 164, the extreme limits of the curve, was divided into 100

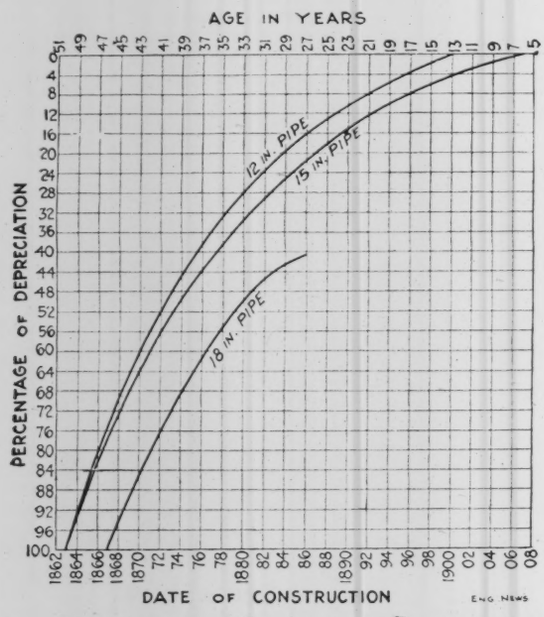


FIG. 3. DIAGRAM FOR ESTIMATING DEPRECIATION OF VITRIFIED PIPE SEWERS DUE TO AGE, MANHATTAN BOROUGH, NEW YORK CITY

parts. From this diagram the percentage of deterioration of sewers built between 1849 and 1883 can be read.

Twenty sewers built before 1849 were examined, nearly every one of which showed a degree of deterioration exceeding the point indicated by 164 on the tabulation, and seemed to justify the assumption that such sewers were without value for the purposes of this valuation. For this reason the curve was ended at the year 1849. Incidentally, this fixed the life of a brick sewer in this borough at about 64 years. For reasons previously given, the other end of the curve was ended near the year 1883.

If a strip of paper of the length of the diagram, giving the cost per foot of sewer divided into 100 parts, be placed alongside of this scale, the money value of such sewer can be directly read from the diagram for any year.

PIPE SEWERS—The attempt to determine the deterioration of pipe sewers by an actual examination like that of the brick sewers did not yield results that could be safely used in a similar way.

Pipe sewers were first laid in this borough about 1865. Up to the year 1887 they were laid on the earth at the bottom of the trench without any other foundation. It required but a slight leak from a joint to wash away the earth enough to permit one end of the pipe to drop sufficiently to begin a serious disturbance of the whole line. In 1887 the present concrete cradle was introduced and the number of disturbances caused by the condition above described was greatly reduced, but, of course, not entirely eliminated.

No wear of the pipe, due to age, is noticeable, and all the deterioration found was due (1) to the cause above indicated and (2) to a tendency of the pipe to break at and above the center, due perhaps to the load imposed on the top or even to some form of disintegration due to this weight. Nearly all of the fractures are on the upper half of the pipe and occur more often in the larger sizes. The sizes used in Manhattan Borough were 12, 15 and 18 in. diameter and these breaks occurred so often in the largest size that its use was discontinued in 1887. It occurred less in the 15-in. pipe and still less in the 12-in.

About 2½ miles of various sizes of pipe sewers were examined by "candling," or by fastening a lighted candle to a caliper and slowly pushing this through the sewer from manhole to manhole by means of rods, while the interior thus lighted up was examined by observers stationed at the manholes. The result was unsatisfactory, and furnished insufficient data to be used alone in determining a value.

It was therefore necessary to find some other means before determination could be made. The only data of value, in addition to the little supplied by the examination just described, were those obtained from the experience gained in renewing and repairing such sewers or in inserting spurs for house connections. In this the writer had the benefit of the knowledge of the men who had been in charge of this work for some twenty-five years, and from that and the examinations described, as well as a great many others made under his supervision, the writer formulated the curves shown in Fig. 3.

Due to the varying strength of the three sizes used, three curves were plotted, the 18-in. curve ending at 1887 when the use of such pipe was discontinued. It will be noticed that a rapid decrease in value is shown in sewers built before 1887. This is due to the construction above described. These curves can be used like those for brick sewers, so that values can be directly read off.

EARTH EXCAVATION AND BACKFILLING—In using any of these diagrams, it must be remembered that the deterioration is confined to the structure itself (the pipe and brickwork) and when this has reached a stage where repairs are no longer economical the sewer will have to be rebuilt. This will involve excavation and refilling as well as repaving. The last item has been fixed at the beginning of this statement, but the two preceding ones are important factors in the cost of replacement and consequently in the present value of the sewer.

When such excavation, at the time of original construction, was in earth, the original cost may fairly be used as a basis in the present valuation, because the same quantity of work would have to be done to replace the sewer, if the subsequent subsurface structures are omitted from consideration. If, however, the whole or part of the original excavation was in rock, the cost of the reconstruction would be considerably reduced below the original amount, due to its previous removal.

For these reasons I have considered the cost of rock excavation an undepreciated asset and used it as a part of the present value of the sewer. It has been our custom to allow one day's working time for the contractor for every 10 or 12 cu.yd. of rock to be excavated. Such an allowance involved one day's pay ($4) for the inspector as well as increased attention on the part of the engineer in charge and his party in visiting the work and measuring and computing the rock, which may be estimated at $1 per day. Added to the inspector's pay this made $5 for every 10 or 12 yd. of rock excavated, or from 40 to 50c. per cu.yd.

If the cost of earth excavation and refilling be assumed at from 40 to 50c. per cu.yd. it will be offset by the "overhead" charges for rock. For example, if the bid for rock excavation is $4 per cu.yd., the "overhead" charges of 50c. will bring the actual cost to $4.50. If the earth excavation costs 50c. per cu.yd. the difference in cost between the two kinds will be $4, the price bid for rock. If, therefore, in determining the value of a sewer when rock excavation was necessary, the bid price of rock is deducted, the remainder will be the cost of that sewer in earth at the present cost of excavation. The cost of the sewer in earth excavation found as above described has been used as a basis of valuation in such cases.

SUPPLEMENTARY NOTES

A study of the maintenance of catch basins developed that their deterioration, although not due to the same causes, proceeded at about the same ratio as that of the

brick sewers. The replacing of basin heads and of grate bars, as well as the injuries caused by subsurface structures, justified the adoption of the same curve of depreciation.

It is important to call attention to the fact that the present value of the sewers, etc., given in the report, is based upon the assumption that in any changes of the sewerage system, the new sewers would be rebuilt in the same location, and that any such reconstruction involving a change of location would leave the present system without any value whatever.

The tabulations accompanying the report, covering 73 pages, 12x13 in. in size, give the kind, size, length in feet, number of manholes, cost per foot, and total cost, as well as value per foot and total value for each size of sewer, together with the cost and value of the catch basins and manholes.

A series of about 7000 reference cards, 5x8 in., was prepared, one for each block of street front in the borough, on which, beside a sketch of the block, was noted all the data mentioned in the foregoing paragraph.

The original computation sheets, from which all this work was copied, in addition to the data already mentioned, contained the date of construction, percentage of depreciation and the contract price and the amount of rock excavation. Where no rock was excavated the contract price of the sewer was used to compute the value. Where rock was found the cost of rock excavation per foot of sewer without depreciation was added to the value of the sewer found as above and the sum was assumed to be the value in such cases. This resulted in a wide variation in the values of the same size of sewer, but it comes nearer the true value than any other method found by the writer.

The following grand summary of the valuation is taken from the report:

RECAPITULATION OF CLASSIFIED SUMMARY OF SEWERS

Kind of sewer	Feet	Manholes	Cost, including manholes	Value
Brick	1,757,414½	16,917	$16,779,932	$13,532,099
Wood	26,249	168	394,034	334,948
Pipe	767,611½	7,298	5,782,485	4,112,076
	2,551,275	24,383	$22,956,451	$17,979,123
	6172 Catch basins		923,875	685,798
			$23,880,326	$18,664,921
	24,383 Manholes		$842,500	$633,304.09

The foregoing summary includes 125 various sizes of brick sewers, 17 sizes of pipe sewers and 23 sizes of wooden sewers, a total of 165 with all kinds of manholes and perhaps 25 varieties of catch basins.

The work of preparing the report, including the cards, extended over a period of about ten months and involved a total expenditure of $6053. It could probably be kept up to date at an annual expense of about $500.

Railway Signal-Interlocking Plants

For several years past the Railroad Commission of Wisconsin has been working in conjunction with the Railroad and Warehouse Commission of Illinois, the Railroad and Warehouse Commission of Minnesota and the Railroad Commission (now Public Service Commission) of Indiana, for a uniform set of rules governing the construction, maintenance and operation of interlocking plants on steam and electric railways. Several conferences have been held at various times at which the signal engineers of practically all the railroads interested in signaling in these four states have been present. It is estimated that one-third of the total mileage of steam railroads as well as a large share of the mileage of electric railways in the United States has been represented at these conferences. The engineers of the commissions have held several conferences independently of those held with the signal engineers of the railroads, and as a result a set of rules has been prepared which the engineers of these four state commissions have agreed upon for submission to their respective commissions for adoption. Accordingly, these rules were submitted to the Wisconsin commission and, after a public hearing, were adopted on Oct. 8, to become effective Dec. 1, 1913. They were adopted by the Illinois Commission, Oct. 22, 1913, to become effective Dec. 1, 1913.

The first eight sections of these rules give procedure of submitting plans for work to be done and putting interlocking plants into service with the approval of the commission. (For 24 hours after completion of work, or until approved as installed, all trains have to stop at the governing home or dwarf signal regardless of its position and the proceed indication is not to be given until after the prescribed stop.

REQUISITES OF INSTALLATION

Section 9. Type of Signals:

(a) Except when approved by the commission, all interlocking signals must be of the semaphore type. The apparatus connected with the operation of these signals must be so constructed that the failure of any part directly controlling the signal will cause it to display its least favorable indication.

(b) Semaphore arms must display indications to the right of the signal post, except where the physical conditions on a road require the display of signal indications to the left.

Section 10. Location of Signals:

(a) All fixed signals must be located, either over or upon the right and next to the track over which train movements are governed, except on roads operating trains with the current of traffic to the left, or where physical conditions require placing the signals to the left of the track.

(b) Bracket post signals may be used on roads operating trains over two or more tracks in the same direction, when such practice is uniform for any specified operation division, or where local conditions require their use.

Section 11. Locking of Signals:

The locking between the levers of the interlocking machine must be arranged so that a home or dwarf signal cannot be cleared for any given route unless all switches, derails, movable-point frogs and other units in the route are in proper position and locked.

Section 12. Home Signals:

(a) When required by the commission, all home signals must be equipped with not less than two arms. Unless operated by power all home signals in mechanical plants must be pipe connected, except when otherwise approved by the commission.

(b) When used in connection with automatic train-stopping devices, the home signal may be located immediately opposite the means for controlling the apparatus of the train-stopping device.

(c) When used in connection with derails and other units the home signal must be located as far in advance of such units as is necessary to secure full protection, but in no case shall it be less than 5 ft. in advance of such units.

(d) When home signals are semi-automatic, or form a part of an automatic block-signal system, calling-on arms or some other means may be used for advancing trains.

(e) All high-speed signals located in automatic block-signal territory shall be semi-automatic and form a part of the block-signal system.

Section 13. Dwarf Signals:

Dwarf signals indicate slow-speed movements and may be used to govern train movements on all tracks other than main tracks, except as hereinafter specified on main tracks to govern train movements against current of traffic, and when approved by the commission as intervening signals to facilitate switching movements. When used they must be located and connected in the same manner as home signals.

Section 14. Advance Signals:

Advance signals may be used when necessary, and must be installed in the same manner as home signals.

Section 15. Distant Signals:

(a) On level and ascending grades, distant signals shall be located not less than 2500 ft. in advance of their respective home signals. On descending grades the minimum distance of 2500 ft. shall be increased at the rate of 100 ft. for each $\frac{1}{10}$ of 1% of gradient.

(b) Where conditions justify, the location and character of distant signals or the method of operation may be varied or the signals be omitted, depending upon the conditions surrounding each particular case.

(c) Except as hereinafter provided, all high-speed tracks must be equipped with power-operated distant signals having electric locks or other suitable apparatus to prevent changing of the route until such signals have indicated their normal position.

(d) When required by the commission, distant signals shall be so arranged as automatically to indicate stop when the track between the home and distant signal is occupied, or when any intervening switch is not in its normal position.

Section 16. Switches:

All switches, derails, movable-point frogs and other units within the interlocking limits hereinbefore defined, must be incorporated in the plant.

Section 17. Derails on Steam Roads:

(a) Main Tracks: On level grades facing derails must be located not less than 500 ft. from a drawbridge or the fouling point of a crossing or junction. On descending grades facing derails must be located to give practically the same measure of protection as for level grades, and the minimum distance of 500 ft. must be increased at the rate of 10 ft. for each $\frac{1}{10}$ of 1% gradient. On ascending grades the minimum distance of 500 ft. may be reduced at the rate of 10 ft. for each $\frac{1}{10}$ of 1% gradient; but in no case shall such derails be located less than 400 ft. from a drawbridge or the fouling point of a crossing or junction.

(b) Pocket Derails: Where such are used, they shall be located so as to derail the first pair of wheels on the ties at a point not less than 50 ft. from the fouling point of a crossing or junction.

(c) Backup Derails: These shall be placed not less than 250 ft. from a drawbridge or the fouling point of a crossing or junction.

(d) Secondary Tracks: All tracks other than main tracks shall be termed secondary tracks. On such tracks derails shall be placed not less than 200 ft. from a drawbridge or from the fouling point of a crossing; and not less than 50 ft. from the fouling point of a junction.

(e) The fouling point is where two trains moving toward a common center would come in contact.

(f) Where conditions justify, the location of derails may be varied or they may be omitted, when approved by the commission.

Section 18. Derails on Electric Roads:

The location of derails on electric roads shall be determined in the same manner as for steam roads. In placing derails in the tracks of such roads, consideration will be given to speed and character of traffic.

Section 19. Type of Derails:

Derails must be of an approved pattern, suitable for the purposes intended, and so placed with reference to curvature, bridges and other tracks as to secure a maximum of efficiency and safety.

Section 20. Guard Rails:

Where physical conditions require their use, guard rails shall be installed in connection with derails. When used, they shall be placed between the track rails, parallel to and not less than 10 in. distant in the clear therefrom, and must be of sufficient height, length and strength, and be properly secured to the track ties.

Section 21. Automatic Train Control:

Automatic train-stopping devices which are a part of a system of automatic train control approved by the commission, may be used in lieu of derails. In such devices, the means for automatically applying the train brakes shall be located a sufficient distance in advance of the fouling point as to insure a safe braking distance.

Section 22. Locks:

(a) In mechanical plants all facing switches, split-point derails in main tracks and all slip switches and movable-point frogs, must be locked with facing-point locks. All other derails, switches and other units must be locked, either with facing-point locks or with switch and lock movements.

(b) In plants equipped with mechanical signals, all derails must be provided with bolt locks; also all switches, movable-point frogs and other units, where conditions require them.

(c) In power plants, the arrangement must be such that the signals operating in connection with derails, facing-point switches and other units cannot be operated unless these units are in proper position.

Section 23. Detector Bars:

(a) Unless otherwise provided, all derails, switches, movable-point frogs and other units shall be equipped with detector bars of approved design not less than 53 ft. in length, or longer if required.

(b) Except as hereinafter provided, all crossings shall be equipped with detector bars of suitable length, so interlocked as to insure a clear crossing before an opposing route can be set up or a proceed signal given.

(c) Crossing detector bars will not be required where electric locking is installed nor at outlying crossings of simple character where no switching is performed, when the plant is equipped with time locks.

Section 24. Time Locks:

Unless equipped with electric locking, time locks must be installed to prevent the changing of high-speed routes, until after the home signal has displayed the stop indication a predetermined time.

Section 25. Electric Locking:

Electric locking may be provided in place of time locks and crossing bars. When used, the circuits must be arranged so as to prevent the changing of a route until the train has passed through the interlocking limits or through a predetermined part of the plant.

Section 26. Detector Circuits:

When a railway company is equipped with sufficient maintenance forces for properly maintaining electric detector circuits, such circuits may be used in place of mechanical detector bars.

Section 27. Machines:

(a) All mechanical interlocking machines shall be equipped with locking of the preliminary type.

(b) All power interlocking machines shall have the locking so arranged as to be effective before the operating conditions of any circuit directly controlling a unit can be changed. Suitable indicating and locking apparatus shall be provided to prevent the placing of a lever in complete normal or reverse position until the unit controlled has completed the intended operation, except that signals shall indicate the normal position only.

Section 28. Locking of Levers:

(a) The locking must be so arranged that conflicting routes cannot be given at any stage in the setting up of a route, nor a proceed indication given until all switches, derails, movable-point frogs, facing-point locks and other units in the route affected are in proper position.

(b) When a separate lever is used to operate distant signals the locking between the home and distant signals shall be so arranged as to prevent the distant signals from giving the proceed indication until the home signals operating in connection with such distant signals are in the proceed position.

Section 29. Locks and Seals:

(a) All interlocking machines must, when practicable, be provided with means for locking or sealing the mechanical locking and indication apparatus in such a manner as to prevent access to any except authorized employees.

(b) All power interlocking cabinets, time locks, time releases, emergency switches, indicator and relay cases must be provided with suitable covers and fastenings and be properly sealed or locked, and must not be opened by any but authorized employees.

Section 30. Cross Protection:

(a) As far as practicable, cross-protection apparatus must be provided in connection with electric interlocking plants to prevent the operation of any unit by cross or grounds.

(b) Low-voltage circuits, as far as practicable, must be designed to prevent the operation of apparatus by cross or grounds.

Section 31. Annunciators:

When operating conditions require annunciators, they shall be installed.

Section 32. Signal Towers:

(a) Signal towers shall be so placed and be of such height and size as to best serve the purpose for which they are intended.

(b) The use of interlocking towers for purposes other than interlocking, dispatching and block work is undesirable.

(c) If work other than interlocking is carried on in the tower, a suitable partition or railing must be provided to pre-

vent outsiders from having access to interlocking apparatus, and interfering with the duties of the operator or towerman.

Section 33. Tower Lights:

The tower light must be screened off so that they cannot be mistaken for signals exhibited to control train movements.

Section 34. Material and Workmanship:

Materials and workmanship must be first-class throughout. When complete, the interlocking plant must be in every way suitable and sufficient for the purposes intended.

MAINTENANCE AND OPERATION

Section 35. Maintenance and Operation:

(a) Interlocking plants must at all times be properly maintained and efficiently operated. Any rules or regulations that the railway companies may have adopted for the guidance of employees in operating and maintaining interlocking plants must be appropriately framed and conveniently placed in interlocking towers.

(b) When an interlocking plant is taken out of service the commission must be notified immediately. Under such circumstances train movements must not be governed by interlocking signals, but by the usual precautions prescribed by statute governing train movements over and across railroad grade crossings, junctions and drawbridges.

Building an Industrial Town in Illinois

A new town now under construction in Illinois is of special interest in that it is located in open farming country at some distance from any center of population, and that its design has been unhampered by any considerations or conditions of existing utilities. The distinct and interesting feature of this enterprise is the application of practical town-planning ideas for an average population in a coal-mining district.

The town is being established by F. S. Peabody and Samuel Insull, of Chicago, mainly as a place of residence for the miners of a coal-mining property recently placed in operation near the townsite and a large electric power station. They represent the Peabody Coal Co. and the Central Illinois Public Service Co.

While the purpose of the enterprise is commercial, it is being carried out on modern lines in regard to planning, public utilities, housing and sociological conditions. At the same time care has been taken to avoid mere beautification and to keep the practical purposes and limitations of the project strictly in mind. For this purpose, frequent consultations were had with John Mitchell, of the miners' union. The town is being established by F. S. Peabody and Samuel Insull, of Chicago, mainly as a place of residence for the miners of a new coal-mining property recently placed in operation.

This new town, which has been named Kincaid, is in the southwestern part of the state, about 20 miles south of Springfield (or 200 miles south of Chicago) and 100 miles north of St. Louis, Mo. It is on a short railway line running west from Taylorville, where it connects with the Wabash R.R. and Baltimore & Ohio Southwestern R.R. The line crosses the Illinois Central R.R. at Pawnee Junction, and extends to Auburn, where it connects with the Chicago & Alton R.R., a total distance of 26 miles. This railway, the Chicago & Illinois Midland R.R., is owned by the same interests which own the mines and the new city, and affords a connection with the four large railway systems noted above. At present, the miners live mainly at Taylorville, 8 miles distant, and go to and from work by trains on the local railway.

The area of the site is about one square mile. It is located on the south fork of the Sangamon River, partly on low-lying land and partly on undulating land, the maximum difference in elevation being about 40 ft. The soil is black loam to a depth of 2 ft., underlaid by compact clay, with the first coal measure at about 35 ft. The plan for the city includes a business district, two residence districts (for buildings of the cheaper and better classes), and an extensive area of park and garden lands. The bank will be owned by Mr. Peabody. The miners' clubs will be operated under control, in order that the liquor problem may be regulated. The design provides for a present and ultimate population of 3000 and 5000. A plan of the town is shown in the accompanying cut.

The part now being laid out is the central section, the subdivision of the eastern and western portions being left for the future. The street plan is laid out to fit the topography, with the public gardens in the lower levels, while the business and residence districts are on the higher ground, with parks and playgrounds interspersed. The city hall is on high ground in the center of the town, while the high school and hotel occupy the summits of two adjacent small knolls.

The width of the main streets in the business district is 80 ft., with a 40-ft. roadway and 20-ft. sidewalks. In the residence districts the width is 60 to 66 ft., with a 24-ft. roadway and 18- to 21-ft. parking, the latter including 5-ft. sidewalks 1 ft. back from the property line. The sidewalks and parking have a slope of 6 in. in 20 ft. The paving for the business district will be brick on a concrete base, while in the residence districts it will be macadam. The alleys are 18 ft. wide.

The sources of water-supply are now being investigated by the engineers. It is planned to put meters on all the services, in order to control the proper use of the water while providing an ample supply.

The sewerage system includes separate storm and sanitary-sewer systems in the business district, and a sanitary system in the residence districts. Flush tanks are provided at all the dead ends. The manholes and flush-tanks are of concrete. Sewage purification is essential, the effluent to be discharged into the river, and as there is very little water (sometimes none) in dry seasons, all chance of nuisance must be provided against. Complete purification will be adopted. All the sanitary sewers are of vitrified pipe, 8 to 15 in. diameter. The sewers are laid in the middle of the streets, with the water mains about 10 ft. from them. An exception to this is at the east end, where the slope of the ground makes it necessary to put the sewers in the alley. Electricity for street and interior lighting will be furnished from the neighboring power plant. This also will supply power for domestic use.

A special feature of the design is the large amount of land reserved for park purposes, this representing 25 to 30% of the total area. A large public park, called "The Meadows," is laid out along the river and two sections of public gardens in the bottom lands have been reserved for the use of the miners. These are laid out in lots, to be rented by householders, and used for growing vegetables, etc. These garden lots are approximately 100x100 ft. As the bottom lands are subject to overflow, a dike or levee is being built to protect the lower part of the residence district from flood waters. Rows of trees and shrubs will be planted along the streets.

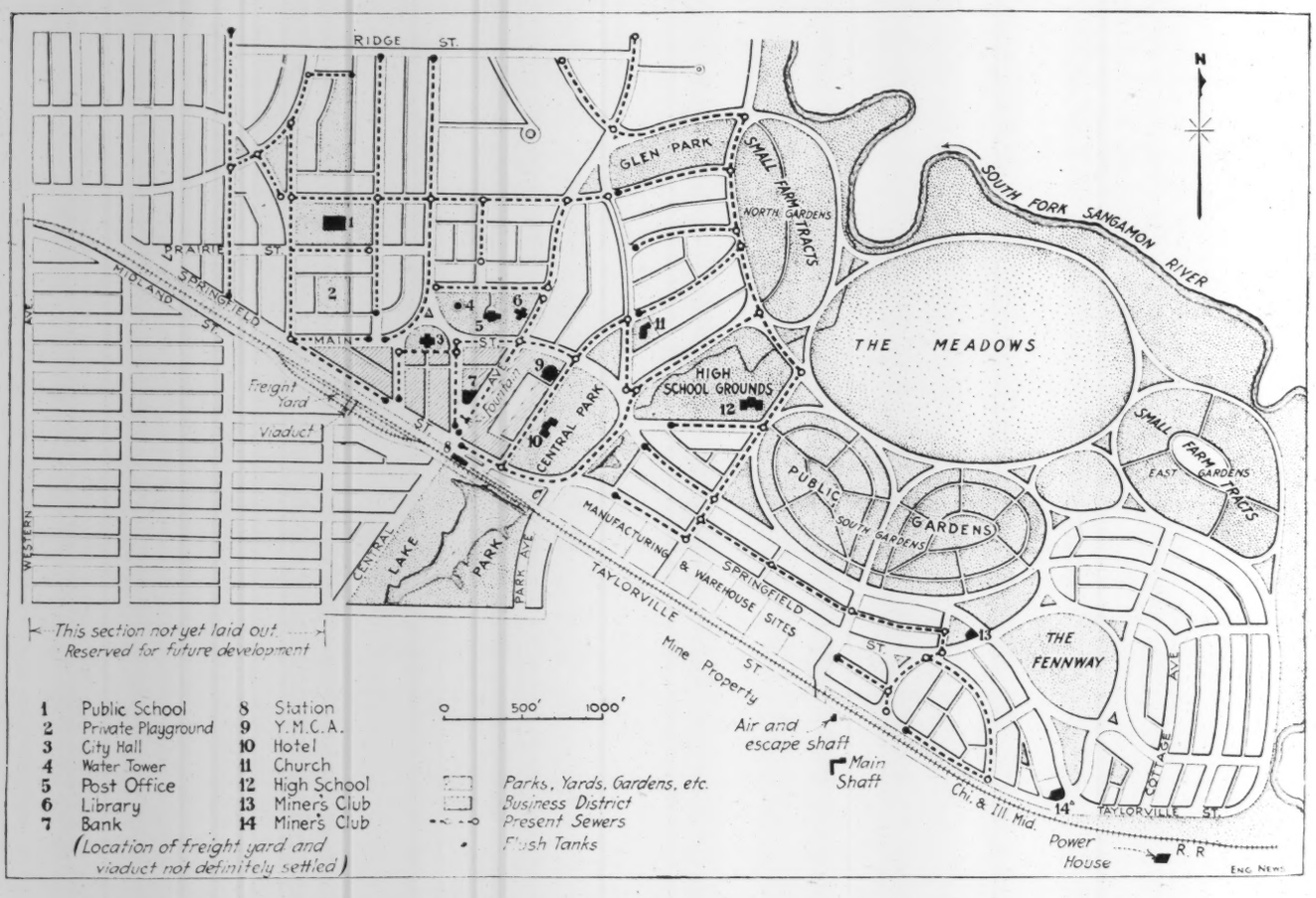
There will be 10 to 12 miles of streets and water mains, and all streets will be provided with sewers. At present, work is in progress on 7 miles of sewers and 7 miles of

street grading. No contracts for street paving have been let, but a contract has been let and work started for 200,000 sq.ft. of concrete sidewalk.

The size of lots ranges from 30 to 125 ft. for the miners' houses to 50x125 ft. (or more) in the better residence section. The company will have designs made for houses of different styles and costs, and purchasers of lots will be allowed a selection from these. The plans will be drawn to provide for modern conditions of good housing, and sanitation, and all buildings will be erected under the supervision of the company's architect. The company will aid in the erection of the city hall, school, high school, postoffice, public library, hotel, and Y. M. C. A. building. A temporary four-room school has been erected already, for the use of the children of farmers in the vicinity. The railway will build a new station. The first stores and prominent buildings of the business district will be designed and built by the company. A number of residences, three store and office buildings and the railway station are under construction, and occupation of the new city will commence within a short time.

The municipal engineers are Alvord & Burdick, of Chicago, who have designed the street, water and sewerage systems and have supervision of the construction. The architect is Geo. W. Maher, and the landscape architect is O. C. Simonds, both of Chicago. All construction work is being done by the Pawnee Construction Co., whose engineer is W. H. Leland. About $100,000 have been spent this year on municipal improvements.

The office methods of the engineers in preparing the design of the city were as follows: in the first place a topographical map was made of the entire area, with 1-ft. contours, to a scale of 1 in. to 100 ft. The streets were then located to fit the topography, and profiles and cross-sections drawn. Then the grades were adopted, together with the widths and forms of cross-section of the streets. Next the sewers were laid out, and sewer profiles drawn. Profiles were then made for the grading, these showing the profiles for the center line and both property lines, with cross-sections for each 100-ft. station. A record map or plat was then made, showing all dimensions. Each lot can be located from $\frac{1}{16}$ corners, which are marked with concrete posts 8 in. square and 4 ft. long, each having a $\frac{3}{4}$-in. brass plug or bolt in the top, with a crosscut in the center of the head. On curved streets a post of wrought-iron pipe is set at each chord point, the pipes being set at accessible places.



PLAN OF THE NEW INDUSTRIAL TOWN OF KINCAID, ILL.

Reference has been made to the large power station built recently in the vicinity. This is about ½ mile from the southeastern corner of the town, being located near the mines and thus assured of a cheap and ready supply of coal for power development. It is designed for an ultimate capacity of 10,000 kw., and will distribute current within a radius of 25 or 30 miles. The plant was designed by Sargent & Lundy, consulting engineers, of Chicago. It is operated by the Central Illinois Public Service Co., which owns a series of power plants and transmission lines.

Editorials

The Index to Volume 70 of ENGINEERING NEWS will go to press about Jan. 10. Readers desiring to receive a copy are requested to mail a request at once to the subscription department of ENGINEERING NEWS and the Index will be mailed to them immediately on publication.

Dispensing with the services of its city engineer to save expense seems to be doubtful economy. This is what has been done at Birmingham, Ala. The city engineer, however, is not the only official to go, and, besides dismissals, salaries have been reduced all around, including those of the three city commissioners. In addition, automobiles for city officials are being given up and other sacrifices are being made. Such drastic measures indicate either dire financial straits or else the desire of a "reform" administration to make a "record." It is reported that the city commissioners have been unable to find any other way of cutting expenses down to meet receipts and are helpless until aid can be secured from the legislature. Birmingham is by no means the first commission-plan city which has attempted to get away from the slovenly old system of deficit financiering and it is not for us to say that it is not acting wisely in going so far as to dispense with the services of its engineer, but this is certainly going to an extreme of economy. It is only fair to say, however, that an assistant engineer will serve as acting city engineer.

A more or less complete blockade to the development of the water-power resources of New York State was removed last November by the passage of a Constitutional Amendment. This amendment opens the way for a limited amount of water storage, under restrictions, in the Adirondack Forest Reserve. Without the amendment it was impossible to develop, at least advantageously, some large water powers, since the dams required would have flooded lands in the Forest Reserve. In some cases only a small percentage of these areas have any trees upon them. Still other constitutional amendments are needed to make the Forest Reserve of more use to the people of the State than is possible under existing restrictions, which were most carefully and rigidly drawn for the express purpose of keeping the Reserve a wilderness.

Valuations of sewerage systems have been few and far between. One involving a large amount of work and possessing a number of interesting features is described elsewhere in this issue. It embraces the sewers of Manhattan Borough, New York City, some of which are of great age. The average life of brick sewers is estimated to be about 64 years and the average depreciation of the sewers of all kinds (mostly brick) and all ages now in use is estimated at 22%. It should be understood that this valuation is based solely on the physical condition of the sewers and takes absolutely no account of the extent to which the present sewers may have become obsolete either as regards design or capacity.

The purpose of the valuation is noteworthy. It was a part of a systematic attempt to ascertain the present value of the property owned by New York City, so as to have such information as is in the possession of every well conducted private corporation. Doubtless the same attempt will be made by other cities, large and small, in the near future. In fact, this information has been requested for several years past by the United States Census Bureau for its yearly bulletin on the "Financial Statistics of Cities." Probably most of the figures given in response to this request have been at best only careful guesses, at least in the case of non-revenue producing public works, like sewers and pavements. It should not be thought that such valuations serve no more useful purpose than to gratify curiosity or pride as to the assets of a city. The life of sewers, for instance, as pointed out in an editorial discussion in our issue of Nov. 27, 1913, is or should be an important factor in determining the life of sewer bonds when such are issued.

Exhibits of Foreign Nations at San Francisco

One might suppose from some of the current newspaper articles that the people of the United States consider the attitude of England and of Germany in refusing to make large expenditures for a government exhibit at the San Francisco Exposition as evidence of unfriendliness to this country. This supposition does little credit to our common sense as a people.

It is far from our desire to discourage or discredit the Exposition. One cannot praise too highly the energy and public spirit which have been displayed by San Francisco in undertaking this vast enterprise so soon after its visitation by the overwhelming calamity of earthquake and fire. Notwithstanding all this, it must be recognized that, in the opinion of intelligent business men who are most familiar with the subject, the usefulness as a means of public education of these great World Expositions, which attempt to include every department of human activity, has very largely ceased.

In the great engineering industries, particularly, a large proportion of European manufacturers are no longer willing to undergo the heavy expense of exhibits at expositions even in Europe itself, where the cost is trifling compared with the cost involved in making an exhibit at San Francisco. In fact we apprehend that here in the United States a very large proportion of manufacturers in the engineering industries are still to be convinced as to the financial wisdom of exhibiting at San Francisco.

Of course where a product appeals to the public so that every visitor who enters the gate is a possible patron and purchaser, such popular Expositions make a strong appeal. Makers of toilet soap and silks and canned goods and sewing machines will, of course, exhibit at San Francisco; but the manufacturer of tools and materials for industrial and engineering establishments finds far better

returns from his expenditure in exhibiting at special conventions and expositions where men of the class he wishes to reach are brought together.

It is, therefore, absurd for us to think of England and Germany as unfriendly to the United States because they are unwilling to spend the several million dollars required to make an adequate exhibit at San Francisco. If the energetic promoters of the Panama-Pacific Exposition cannot convince England and Germany that it will pay them to come in and exhibit that should be an end of the matter. It becomes a matter where emphatic public protest is warranted, however, if attempt to compel nations to undertake exhibits by the declaration that a refusal to participate will be construed as evidence of unfriendliness to the United States.

It is of great interest, as showing the genuine good will felt toward us on the other side of the water, that some of the prominent newspapers there are urging that the government ought spend the several millions of dollars required, understanding fully that it will be an expenditure not worth while save as an evidence of their good will toward this nation.

We heartily commend this evidence of international good will to the attention of our own Congress. Only a few months ago in these columns we explained how Congress has absolutely cut off this country from official participation in any International Congress whatever by the passage of a law forbidding the expenditure of any public money for the sending of delegates to such Congresses or paying their expenses. If the United States begrudgingly refuses a few thousand dollars per annum in order that the nation may officially take part with other nations of the world in international congresses devoted to the promotion of science, engineering, philanthropy, industry and other movements in which the world at large is vitally interested, with what grace can we call unfriendly the action of other nations in hesitating to spend millions of dollars for participation in a commercial exposition on our own soil?

Tonnage Measurements for Vessels Passing through the Panama Canal

We have received a formidable looking document headed: "By the President of the United States of America; a Proclamation," and bearing the signature of Woodrow Wilson and Secretary of State, W. J. Bryan. The document states that "the President does hereby prescribe and proclaim the rules for the measurement of vessels for the Panama Canal, which are annexed hereto and made a part of this proclamation." The rules which are thus made authoritative comprise a quarto pamphlet of no less than 20 pages.

The question is often asked, What is the tonnage of a vessel? As those of our readers who have given any attention to the matter are aware, there are three ways of expressing a vessel's tonnage: as gross tonnage, net tonnage, and tonnage displacement. The tonnage displacement is measured in tons of 2240 lb., and refers to the actual weight of the water displaced by the hull of a vessel.

For assessing Panama Canal tolls, warships passing through the canal are to be taxed on their tonnage displacement, "which is to be determined from the vessel's official displacement scale and curves," in connection with the draft, measured at the time of the application for passing through the canal. For the determination of the mean draft, a warship must be placed at such location as the Governor of the Panama Canal shall order.

An interesting complication in measurement may arise here over the question as to the draft of a vessel in salt water or in brackish water. If the draft of the vessels is taken at the approach to the lowest lock, either at Gatun or at Miraflores, it is probable that the water will be fresh, or nearly so at least, when traffic through the canal is sufficient to require a large volume of water for lockage, so as to continually flush the channel below with fresh water. There may be conditions, however, in which the surface water will be fresh, but the water near the bottom will be salt, and it will be a puzzle to know what factor to use in converting the total volume displaced by the vessel into tons of weight.

All other vessels than war vessels passing through the Canal are to pay tolls based on their net tonnage. The bulk of the pamphlet is taken up with detailed rules for computing the gross and net tonnage. The gross tonnage is defined as "the exact cubical contents of all spaces below the upper deck of a vessel and of all permanently covered and closed-in spaces on or above that deck," except such as are in the rules specifically exempted. To obtain the net tonnage, there is deducted from the gross tonnage the capacity of spaces, such as the engine and boiler rooms, which are not available for the accommodation of passengers or freight. The cubic capacity, when measured in cubic feet, is converted into tons by dividing the total by 100.

It is, of course, true that the tonnage measurement of vessels is based on long established custom. The computations and uncertainties which it involves, however, are wholly out of accord with present-day commercial practice. Variations in tonnage measurements in different countries by different sets of rules is such that the tonnage of a vessel may vary by a considerable percentage according to the system by which it is measured.

It seems a pity that in the opening of the Panama Canal, the opportunity was not taken advantage of to establish, in place of the antiquated system of tonnage measurement, some simple system of measuring vessels passing through the Canal, which should be easy of determination, and which might be the first step toward an international standard for vessel rating.

It is well known that the arbitrary character of the usual rules for measuring net tonnage and the fact that net tonnage forms the basis upon which taxes, insurance rates, port dues, etc., are assessed, has resulted in considerable freak work in ship designing and has placed a premium on the practice of carrying cargo on deck, protected only by such shelter as will not bring the space within the statutory requirements. It would be entirely possible to adopt a system of measurements for vessels passing through the Panama Canal, for assessing tolls which would avoid all the complications of the antiquated net tonnage measurement. Our contemporary, *International Marine Engineering*, suggests that the simple block measurement of each vessel, multiplying the length on the load water line by the beam, and the product by the draft and then assessing a toll of one cent on each cubic foot of the prism thus defined would be

practically equivalent to the present rate of $1 per net registered ton on the average merchant vessel.

Some such simple system of vessel measurement, which may be easily made by the canal operating force, would save a vast amount of possible delay and controversy in the future over the measurement and toll rate of vessels passing through the Canal.

Land Subsidence over Coal Workings

A difficult engineering problem on which a great deal of study has been expended in the coal-mining districts of Europe is becoming extremely acute in certain parts of the Pennsylvania anthracite fields.

The city of Plymouth, in Luzerne County, with a population of some 18,000, is underlaid by the workings of the Plymouth Coal Co. The engineering firm of Harrison & Butts, of Wilkes-Barre, has recently made for the city authorities of Plymouth an examination of these coal workings and rendered a report of its findings. The coal company's workings cover an area of about 150 acres, located beneath the largest and most compactly built-up portion of the city of Plymouth. Marked subsidence of this entire area has already occurred. Many buildings are out of plumb and in some cases are broken through from top to bottom. A large sewer in Main St. has been broken and the grade of the street has been so altered by subsidence as to necessitate the construction of an entirely new 36-in. storm-water sewer.

There are seven coal seams underlying Plymouth, the thinnest averaging 5 ft. in thickness and the thickest averaging 22 ft. The coal seam nearest the surface has about 30 ft. of rock cover, above which is a depth of 10 to 50 ft. of sand and gravel. The lowest coal seam worked is at a depth of about 800 ft. The total volume of coal which has been removed from these various seams over the 150 acres of area, is from 8,000,000 to 10,000,000 cu.yd. In some of the seams as much as 70% of the coal has been mined, leaving only 30% of its area in pillars to support the surface. Many of these pillars are broken and partly crushed already.

While a small amount of work has been done in sluicing culm and refuse back into the seams to take the place of the coal removed, the work has been unsystematic and no great account can be made of the filling heretofore placed as a guard against subsidence. Further than that, the engineers report that if all the available slate, mine refuse and surface material within the vicinity of the collieries were to be sluiced back into the workings, the total amount would only be two or three million cubic yards, or a little more than a quarter of the amount required to replace the coal which has been removed.

It will be apparent, therefore, that the section of the city above these underground workings is supported only by the rock roof, the slow yielding of which has already become evident. The engineers say in their report "should the roof break, as further mining would cause it to do, the surface would fall to a depth which might entail a catastrophe."

Similar conditions, more or less serious, exist also at other towns and cities in the anthracite region and present an engineering and economic problem of the gravest difficulty. With the rapidly diminishing stores of anthracite, it is on the one hand exceedingly important for the conservation of the supply that as much as possible of the coal in the seams should be mined and saved. It seems little short of a crime against posterity that we are today taking from the coal seams by our mining processes only half to two-thirds of their entire contents and in soft-coal mining even a smaller proportion, leaving the remainder forever locked up and irrecoverable. On the other hand, the growth of population and of cities in the coal regions has brought about the construction on the surface in many places of improvements so valuable that their destruction by subsidence must be guarded against even at large expense, to say nothing of the risk to human lives at stake. That it will eventually become necessary to replace by some sort of filling the space in the seams left vacant by the removal of coal, there seems little reason to doubt. If, however, such filling were to be made compulsory, the added expense to mining operations would be equivalent to stopping all mining under the cities threatened by subsidence, since coal won there would have to compete with coal taken from areas where no such safeguarding was necessary.

Filler for the Joints of Brick Pavement

In our issue of Dec. 11 we published the proposed specifications for New York State highway work drafted by the firm of Blanchard & Hubbard for the New York Department of Efficiency and Economy. A remarkable feature in these specifications, which has received general criticism since they were published, is the requirement that the joints in brick or stone pavements should be filled with asphalt instead of cement. The reason for this requirement, given by Blanchard & Hubbard, is "that asphalt is more durable on account of its elasticity and is less noisy and much easier to repair."

It is true that there are some engineers who still adhere to the old practice of using asphalt filler for the joints of stone and brick paving; but we believe such engineers are in a small minority. The leading engineers responsible for street-paving design and construction are substantially agreed, we believe, that the use of properly mixed and properly placed cement grout in place of soft filler constitutes one of the most important improvements in brick paving practice that has taken place in decades. A grouted pavement becomes practically a continuous sheet. The bond of one brick or stone with those adjacent to it is so strong that it is practically impossible by any blow of traffic for a brick to be loosened and forced down lower than its neighbors. Again, the hard grout-filled joint protects the corners of the brick or stone, so that they are not rounded off by the attrition of horses' hoofs, as always happens in a few years on pavements where the joints are filled with bituminous materials.

Such smooth-surfaced pavements can be kept clean and sanitary with far less expense than the old type of pavements, where dirt always lodged in the joints as soon as the pavement became at all worn. Still further, the grouted joints cost less than the asphalt-filled joints, and a workmanlike job is much more easily secured with ordinary labor.

To offset all these advantages it is said, by Messrs. Blanchard & Hubbard, that the asphalt-filled joint is preferable because the pavement is more elastic (which means doubtless that less pains is necessary in the provision of expansion joints to provide for temperature movements in the pavement) and that openings in the pavement for repair are more readily made, while the pavement is also less noisy.

Even if the asphalt-filled pavements were proved to be superior in these respects, we do not think these considerations are sufficient to offset the important advantages above enumerated. It is not believed, however, that there really is a large difference in respect to these qualities between the two types of pavement. It has proved to be entirely practicable to so lay a grout-filled brick pavement that no serious trouble will occur from contraction and expansion. As to the difference in labor cost in making an opening in a pavement with soft filler or with grout, it cannot be very great. Even if it were considerable, however, it must be remembered that the specifications we are considering are not for city streets, but for country roads, on which it should rarely be necessary to make any openings in the pavement when once properly laid. In such locations at least, there would be no reason to select the asphalt filler because of more convenient repair.

As for the relative noise of traffic on the two classes of pavement, there appears to be little to choose. It is of interest to note that on the new paving work which is being done by the City of Baltimore, perhaps the largest task of street paving now under way in the United States, brick paving with cement grout filler has been laid on the street passing the city hospital.

It must be borne in mind, too, that the whole paving question has a different aspect today by reason of the rapidly growing preponderance of motor traffic over horse traffic. The secure footholds for horses' calks afforded by the open joints of the old-time tar-filled brick or stone-block pavement are no longer essential. On the contrary, the nearer to a smooth plane surface a street can be kept, the less the wear and tear upon motor vehicles of all classes and the less the wear and tear also on the pavement itself. With the rubber-tired traffic of motor vehicles, also, one pavement is as good as another so far as noise is concerned. Any engineer interested in street-paving methods who is still unconvinced as to the superiority of grout filler over cement filler for brick paving would do well to make a short tour of inspection in some of the cities of the Middle West where brick paving has been in use for a dozen to twenty years. An examination of the relative condition of pavement of both these types which have been subjected to several years' wear will convince the most skeptical.

As to what practice will finally be adopted in the New York highway specifications, one may well hesitate to prophesy in view of the kaleidoscopic changes which have taken place in New York highway administration during the past few months. We are informed on good authority, however, that so far as the recommendation of Messrs. Blanchard & Hubbard above discussed is concerned, those at present in authority have no intention of adopting it in their practice. Indeed, according to published newspaper statements, Commissioner Carlisle, the head of the New York Highway Department, has become so disgusted with the pulling and hauling, the charges and countercharges between the various asphalt, and tar, and oil interests that he is in favor of abolishing the use of bituminous materials entirely in state-road work and building only gravel, macadam, brick or stone-paved roads.

Letters to the Editor

The "Economical Concrete Design"

Sir—In the communication by Edward Godfrey in your issue of Dec. 18, 1913, p. 1252, he asks how the writer interprets the clause in the report of the Special Committee on Concrete and Reinforced Concrete which states that "For concentric compression on a plain concrete column or pier, the length of which does not exceed 12 diameters, 22.5% of the compressive strength may be allowed."

If Mr. Godfrey will read this clause in connection with the last paragraph in Section 1, Chapter VII, and the first paragraph of Section 9, Chapter VII of the same report, it would seem as if he would be convinced that his design is not in accordance with the report of the Special Committee. It is quite possible that the wording of the report can be made clearer than it is, but it does not seem to the writer that the emergency is quite as serious as Mr. Godfrey would have it appear.

J. R. Worcester.

Boston, Mass., Dec. 26, 1913.

[The two paragraphs noted above by Mr. Worcester are as follows:

Massive concrete is suitable for dams, retaining walls, and piers and short columns in which the ratio of length to least width is relatively small. Under ordinary conditions, this ratio should not exceed six. It is also suitable for arches of moderate span, where the conditions as to foundations are favorable.

By columns are meant compression members of which the ratio of unsupported length to least width exceeds about six and which are provided with reinforcement of one of the forms hereafter described.

—Ed.]

Relation between Engineering and Art

Sir—Engineering and art have a relationship not yet fully appreciated by the engineers, the artists, and those who combine the two professions—the architects—of the United States. The American engineer has the greatest opportunity in the world to design and to erect artistic buildings of the reinforced-concrete type because he

is not restricted to certain conventional classes of architecture, as is largely the case with European engineers.

American engineers are beginning to attempt the harmonious combining of the two professions, but they have much to learn. To substantiate this, note the latest and greatest New York skyscraper—the Woolworth Building; it is a work of art, in proportions, but an eyesore to artists, as regards ornamentation. Scrape off the latter and you have a beautiful edifice.

Correct proportion is the only quality which can give real and permanent beauty to a structure. With few exceptions ornaments are applied only as cloaks to imperfections—to hide defects in design. To test the harmony of a structure and an ornament, the following rule is a good guide: An ornament which can be removed from a building, without leaving an evident void, is a superfluity and does not add to the beauty of the structure. As I understand it, an ornament should constitute an ornamented *part of the construction*, and should be permitted to exist only when it contributes to the beauty of the whole.

If this is not the case, and the ornament is additional to the construction, it is analogous to an overdressed lady. If she is personally beautiful, she does not require (should absolutely reject) the anti-climax of super, if not indeed gaudy and tawdry, ornamentation. If she is not beautiful—well, that is another matter; the analogy ends here, for her designer is beyond our condemnation. This, however, is the lesson: True lines represent beauty—not the qualification and complication of such lines.

American engineers and architects do not yet realize what an advantage they possess over their European colleagues, in that they are not reared amid examples of the architecture of a decadent period (from the close of the 17th century until now). It takes years to forget all that rubbish, and to learn that simplicity is the best quality both in engineering and art, and ornamentation is but a small branch of art, and entirely distinct from structural design.

WILLIAM HOEKER.

24 Plaats, The Hague, Holland, Nov. 25, 1913.

Paying for Concrete According to Its Strength

Sir—The communication of Robert C. Barnett in your issue of Dec. 25, 1913, p. 1314, is rather interesting in that the author suggests paying for concrete according to its strength as a means for securing stronger concrete structures. The value of such a method seems questionable and may even encourage indifferent work; it gives the incompetent contractor a liberty which he might abuse. If a structure is designed for concrete of given strength, it seems that such a concrete should be specified and used; the use of a weaker concrete might be absolutely dangerous.

If the weaker concrete is strong enough to carry the required loads with the size of members indicated on design, then economical engineering would demand that the weaker concrete be specified. Under the suggested scheme, the stronger concrete could be specified and required by the design and then should the tests show the concrete to be used as of inferior strength, the contractor would be permitted to use it and be paid for it at a reduced rate. The contractor will find it cheaper to accept a reduced rate for poor concrete already poured than to tear out and replace it with proper concrete. Mr. Barnett suggests that under the proposed scheme the contractor will exert every effort to secure the strongest concrete possible; this is true, but unless very strict supervision is maintained and skilled labor employed, it is possible that a great amount of concrete will be poorly mixed. It may even be cheaper for the "skin" contractor to employ cheap labor and poor superintendence and accept the reduced rate for poor concrete.

It seems that a more effective way of securing stronger concrete structures is stated in the beginning of Mr. Barnett's letter. The specifications should state distinctly just what strength is expected of the concrete and that the contractor will be required to furnish concrete whose strength is reasonably close to that specified. Close engineering supervision should be maintained and tests frequently made. If the concrete runs below the proper strength, then the contractor can be warned and made to remove any dangerous work. It seems that it is better to prevent the use of or to reject weak, inferior concrete, accidentally or otherwise made, than to accept it and pay for it at a reduced rate.

CHAS. D. CONKLIN, JR.

Cheltenham, Penn., Dec. 29, 1913.

Sir—Mr. Barnett's communication is very practical and suggests an efficient remedy for an existing evil in concrete construction, the importance of which has not been generally recognized but which, if observed in the construction of buildings in general, would overcome many of the difficulties now experienced in obtaining sufficient time for mixing the batch, and care in the handling and placing of same afterwards.

It would prevent many of the difficulties and controversies which are now of almost daily occurrence between the contractor and the engineer on concrete jobs as to what is the proper length of time to leave the batch in the mix and impress the contractor with some realization of the real importance of properly made concrete. I believe I voice the experience of all engineers who have had charge of concrete construction work, when I state that the average contractor has no other comprehension of concrete save that it is just a mixture of the aggregates and cement in the prescribed proportions with a certain amount of water; and that the more economically he can "jumble" it together and dump it in the forms the better work he is doing.

This suggested crushing test and the application of the results will naturally force a more intelligent realization of the facts pertaining to the qualities of concrete than days of heated argument; and the proper incorporation of requirements into the specifications, and then their enforcement as the construction proceeds, will thus have the threefold advantage of obtaining better concrete, preventing premature form removals and the enlightenment of the contractors as to the reasonableness of the engineers' requirements.

It seems possible too that it might indirectly suggest to the "commercial designers" of reinforced concrete, that there are other considerations than economy in the amount of steel used and the time and ability expended upon their plans.

A. C. AREND.

Omaha, Neb., Dec. 27, 1913.

Further Notes on the Collapse of the Stark-Lyman Building, Cedar Rapids, Iowa

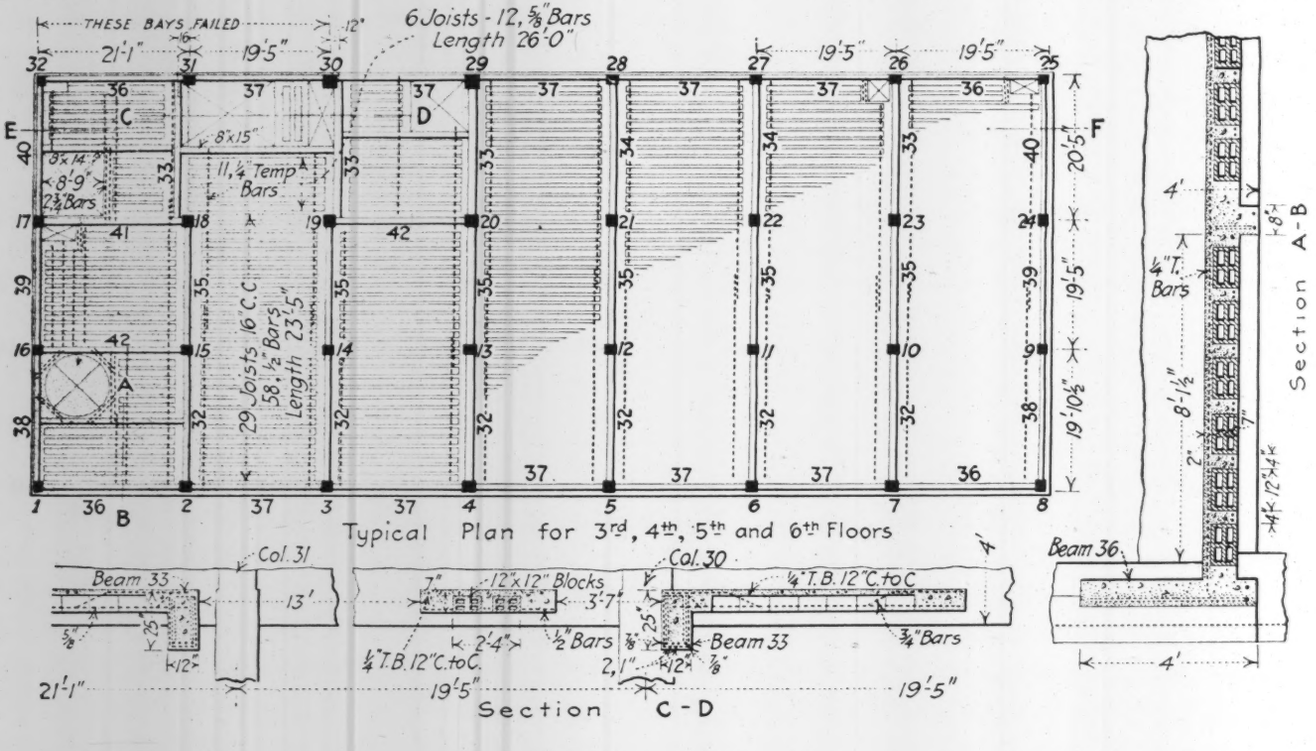
We give below extracts of two separate reports on the failure of the Stark-Lyman reinforced-concrete building at Cedar Rapids, Iowa, which occurred on Nov. 14, 1913.*

The two reports agree in assigning as a primary cause of the failure the retardation of the set of the concrete, due to the low temperature after pouring, but one of the reports lays particular stress upon the excess loading from the falsework, while the other points out, as the secondary cause of failure, a weak connection between beam, girder and column, in one of the upper floors of the building. It may be noted also that it is here brought out that in the upper floors the columns were reinforced merely with straight rods, and that the hooping, hitherto described as being in the columns, reached only to the fourth floor of the building.

The first report given below is an abstract of one presented by C. A. P. Turner, of Minneapolis, Minn., to the Master Builders' Association of the State of Iowa. Mr. Turner was called in by that Association to investigate the failure of the building, and the report made by him to the Association has been put at our service. In order to make Mr. Turner's report readily intelligible to the reader, we present herewith drawings made from information furnished by Mr. Turner showing the typical floor plan of the upper floors as designed and a statement as to the beams and beam reinforcement on these floors.

Mr. Turner states that in the interior columns of the building the design shown was not followed in actual construction, circular columns of approximately equivalent area having been substituted for the square sections. Whether there were other deviations from the original design, we are not informed.

*"Engineering News," Nov. 27, 1913, p. 1104; Dec. 18, 1913, p. 1254.



(Interior columns were built circular instead of square as shown. A typical column make-up is given below.)

COLUMN SCHEDULE FOR COLUMN 18

	Basement	1st	2d	3d	4th	5th	6th	7th
					story			
Section, in...	23x23	21x21	18x18	18x18	16x16	16x16	14x14	12x12
Long. reinf...	8, 1 3/8-in.	8, 1 3/8-in.	8, 1 1/8-in.	8, 1-in.	8, 1-in.	4, 3/4-in.	4, 3/4-in.	4, 1/2-in.
Spiral								
Diam.....	20-in.	18	15	15				
Pitch.....	2-in.	1 1/2	1 1/2	1 1/2	—	—	—	—
Rod.....	3/8-in.	5/16	5/16	1/4				
Ties								
Rod.....	—	—	—	—	3/4-in.	3/4	3/4	3/4
Spacing...					12-in.	12	12	12

Col. 19, scheduled the same as Col. 18, measured at 5th floor, 19 1/2 in. in diam.

FIG. 1. FLOOR PLANS AND BEAM DETAILS OF STARK-LYMAN BLDG., CEDAR RAPIDS, IOWA

Mr. Turner's report reads in part as follows:

The building under consideration was not what should be strictly called a reinforced-concrete building. It was so only in part. It presents a combination of hollow tile, concrete and steel. The floors throughout were made up in a large part of tile, with thin, narrow joists of concrete between the separate tiles; and a skimpy layer of two inches of concrete covering the tile on top, these joists being each reinforced with two twisted rods.

The details of the floors may be characterized as a combined beam and slab construction, in which the beams run crosswise of the building and the slabs span from beam to beam. The reinforcement is a one-way type, and the joist between the tile is nominally 4 in.; but as is usual in this kind of construction, the alignment of the tile varies somewhat, and the width of the joist varies with the alignment. There are a number of places where there are slight imperfections in the casting, pockets are formed, though not to such an extent as seriously to impair the degree of strength usually secured by the arrangement adopted. In the upper floors, the tile used was 7 in. deep by 12x12 in. in plan, sup-

proximately. These tile were moderately hard burned, with a ½- to ⅝-in. shell.

The reinforcement of this building consisted of square twisted bars, which showed by the manner in which they were bent that the material was tough and of a reasonably fair quality.

A careful examination of the broken concrete indicated beyond question that a liberal amount of cement had been used throughout, and that the concrete itself was of unusually good quality. The sand found on the job was exceptionally good, the rock of fair grade. There was noted this striking characteristic in nearly all fractures of concrete observed: that it all presented a clean cut cleavage of the stone aggregate, including those on the fourth and fifth floors.

The lower tiers of columns are of hooped and vertically reinforced type. This hooping is found on most columns as low as the fourth tier, and on some lower than that. From this point upward the columns are reinforced in the main with either four or eight rods vertically, and tied 12 or 15 in. apart. These rods are from ⅞ to ⅜ in. in diameter. In this connection, pointed attention should be called to the characteristics of these two respective types of column reinforcement. A hooped column, with hoops binding the core, holding it in shape under excessive load, or where the concrete is not thoroughly cured, renders this type tough, reliable and safe, so that an accident with it is nearly or almost out of the question. The second type of column, that is, with vertical reinforcement of ties at intervals of 12 to 14 in., have little or no toughness. The concrete body is not well bound together, so that unless the concrete is well cured and hardened, sudden collapse and failure may readily occur without any warning whatsoever. That is, the column will fail by simply bulging out between the ties, and everything in the vicinity will drop, in a collapse of this kind, so quickly, that it will be almost impossible for the eye to detect which part of the structure failed first.

Some of the most important beams of the structure were provided with no stirrups whatever, reinforcement at the bottom and top of the beam respectively being parallel to the center line of the beam for some distance from the support. Reinforcement, which was carried up to the top of the beam, was carried out a considerable distance from the support and then bent down sharply, affording, in this unscientific position, little or no assistance to the concrete in shear, at the time when it needed this assistance most, that is, in the partly cured condition. This radical departure from good practice, in leaving out stirrups and in improper bending of beam rods, we find in the important member, Beam 41, in which Beam 33 frames as an offset in the upper story, going by Column 18. This detail will be referred to later.

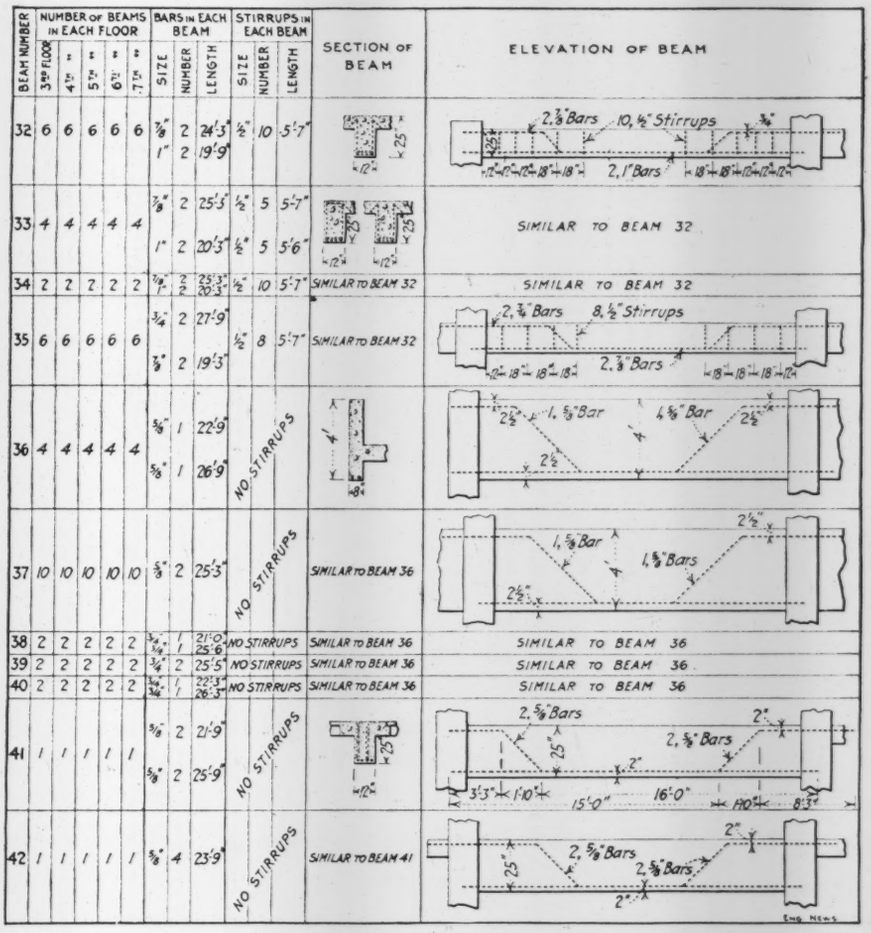


FIG. 2. BEAM SCHEDULE FOR STARK-LYMAN BUILDING

Mr. Turner then refers to the temperature conditions existing during the construction of the building. The temperatures and the dates of the casting of the various floors are given further along in this article (Fig. 3). In commenting upon the conditions noted there, Mr. Turner says:

About Oct. 13, the fifth floor was poured, the minimum temperature at that time running below 50° F. Following the line of minimum temperature, it will be seen that it drops rapidly from 50° to 21° and 22° above zero on Oct. 20, before the fifth floor was finished, and work started on the next floor. The concrete, contrary to good engineering practice, was mixed with cold water, and hence, as experience teaches us, the hardening occurring in the concrete so cast must have been very slow indeed. This would be particularly true in the concrete of the column boxes. That which was cast in the slabs, on account of the absorption of the excess moisture by the tile, would harden with much greater rapidity, and might be expected to develop a reasonable compressive resistance, between this period and the period in which the collapse occurred, especially in view of the fact that from Oct. 22 to 26 the maximum temperature rose above 60°. The air and sun would strike more or less on the top surface of the floor, while the columns would not be subject to such favorable conditions, particularly in that part of the columns immediately below the floor.

If we are to place concrete in the fall of the year in a temperature ranging from below 50° down to 20° and 10° above zero, we can readily do so and secure the same degree of rapidity in hardening that is secured in the warm summer weather, by the simple and comparatively inexpensive expedient of heating the water of the mix, thus waking the cement up so that the chemical action of hardening progresses with the same degree or approximately the same degree of rapidity as it does in the warm summer season. There was ample time between Oct. 13 and Nov. 14 for this concrete to have become well cured, or sufficiently well cured to become dependable and safe had this simple precaution been taken.

SPECIFIC CAUSES OF THE FAILURE

In Beam 41 framing into Column 18 on the upper floors there is a weak member, deficient in reinforcement where Beam 33 frames into it. The shear on the concrete in this beam in its partly cured condition is higher than is ordinarily considered permissible with old and cured concrete. This fact combined with the unquestionably soft condition of the concrete due to the chilly weather and the fact that the column reinforcement where Beam 41 frames into it at the fifth floor and at the top of the fourth tier of columns above the basement, consisted merely of vertical rods with ties at considerable intervals apart, makes this point, in the writer's judgment, the initial point of failure. The giving way of the column at this junction of the beam and column would cause a wrenching through Beam 35 of Column 15, and the almost instantaneous collapse of the two end bays of the building. This conclusion is in accord with the manner in which the failure occurred, and seems substantiated by what evidence has been given by various witnesses at the coroner's inquest.

It has been suggested by some that the settlement of the supports may have had something to do with the failure. Careful levels were taken by the writer upon the center line of columns transversely of the building in the section which collapsed, and no change in level was discovered. It is impossible to account for the collapse on this ground. The fact that the failure was instantaneous or nearly so would preclude the possibility of the adoption of the theory that failure of the centering was the cause of the collapse. As has been suggested by some who held to the idea that the small amount of concrete which had been poured on the roof above the seventh floor over an insignificant area may have produced the collapse through failure of the supporting forms. A collapse of this character would be accompanied by a kind of step by step failure as was noted distinctly in the collapse of the Long Beach Hotel.* when the upper floor came down first and one floor after another followed. In the case under discussion, however, this phenomenon was absent and a careful consideration of all facts seems to determine with a high degree of certainty the manner of failure as above advanced.

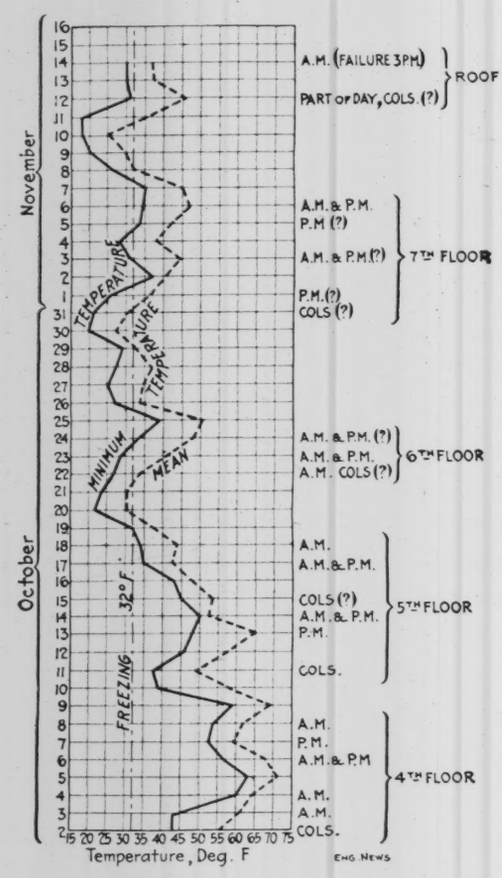


FIG. 3. TEMPERATURE RECORD, OCT.-NOV., 1913 AT CEDAR RAPIDS, IOWA, AND DATES OF POURING CONCRETE, AT STARK-LYMAN BUILDING

As is invariably the case where collapses occur, that part of the work which has not been executed as well as it could be is immediately noticed, and an effort made to associate it with the prime cause of failure, or indeed to attribute the collapse itself to such small and perhaps innocent defects as may be found. Certain defects in the get-up of the falsework have been seized upon by some as an explanation of this failure, and it is not to be denied that the general get-up of the falsework used by the contractor, and approved by the engineer in charge of the work, did not exhibit engineering skill, and was not as perfect in get-up as a fair consideration of economy, combined with the highest degree of safety, would demand. While we may credit the carpenter who built it with possessing that degree of ordinary skill legally required of the craftsman, the writer will frankly state that in his view the contractor making a practice of building forms of the kind and the character employed in this building needs the assistance of a consulting carpenter. The writer has used the expression consulting carpenter in the sense of an expert mechanic, for the reason that too many of the engineering profession, while somewhat familiar with higher mathematics, do not possess practical ingenuity sufficient to devise an economical and creditable job of rough carpenter work.

In concluding the report a word regarding the fact of the design being submitted by the steel contractor to a consulting engineer of Chicago is in order. The scope of this engineer's report was to determine whether a certain set of rules had been followed in the mechanical operation of computing the strength of the design. Apparently he was not called upon to report on the hazard of erection, or upon safe methods of erection, or upon the relative safety of this design, as compared with others of approximately the same cost or of greater economy. The mere checking of a design and finding that the plans comply fully with a specification of the engineer for the owner, does not settle the question as to whether the design was a safe one from the standpoint of the general public interested in such fellow members of the community as were employed as workmen in the construction of the building.

The specifications of the engineers for the owners allow 20,000 lb. per sq.in. in mild steel, for an exceedingly light structure. In a light structure we have the condition that the rated live load does not materially exceed the dead load, and consequently in the course of erection the partly set concrete is invariably strained to a far greater degree than is the case where the ratio of the dead weight of the construction is but a small fraction of the live load capacity. This causes the structural design for light loads to involve a much greater hazard of erection than the structure of design for heavy loads. This consideration brings out more forcibly the reason why none but the most conservative type of detail should be employed in the lightest class of structure.

CHANGES IN DESIGN

Mr. Bishop, engineer in charge of the work for the owner, credits the contractor with having put up the building just as the plans called for. This is undoubtedly intended to be a fair statement, but it is not a correct statement of the facts, inasmuch as it does not do sufficient justice to the contractor. The contractor put up a better building and a stronger building than the plans called for. He made the following changes in the plans: He proposed using round columns, expecting there would be some economy in the interior columns, but after having secured permission to make this change, on figuring it over he found that there would be an actual loss by making this change, and he wanted to go back for that reason to the square form shown on the owner's design, but the engineer for the owner is credited with having objected to this change back to the original plan. Accordingly we find that the weak point above noted, that is, the top of the column under the fifth floor, at Beam 41, an increase in cross-section of the concrete of fully 20% over and above the cross-section required by the engineer's design as adopted by the owner, and figured on by the contractor, and a corresponding increase in the strength of the structure at this point at the time of failure of not less than 35 or 40%, taking into consideration the beam and column connection.

In conclusion, it may be noted that Mr. Turner considers that it is not the contractor's duty to provide against the retardation of set of the concrete. His opinions in this regard are as follows:

The writer will make the pointed criticism that, while the concrete mixture was of the right consistency and strength, Mr. Bishop, the engineer for the owner, did not see that it was of the right temperature to properly harden in the range of temperature which existed. The ordinary contractor is not supposed, as is the engineer, to have had any training in the fundamental or elementary principles of chemistry. He is not supposed, except he be taught by the engineer or cement chemist, or has learned by observation, that time is only one of the elements entering into the hardening of portland cement concrete. The temperature plays a more important part in the curing of concrete than the number of days which may have elapsed since the concrete was placed in the forms. We should look not to the contractor for information or instruction, but to the supposedly educated engineer in charge of the job, to see that such an exceedingly important yet simple detail in the execution of the work is given the attention which its vital importance demands.

*"Engineering News," Vol. 56, 1906, ii.

Report on Falsework Loads

The second report is based on an analysis made by an engineer who had some responsibility in connection with the design of the building. This analysis is intended to show that the weight of the 6th and 7th floors, which were in a state of imperfect set, owing to adverse temperature conditions, was being carried through the falsework to the 5th floor, and this floor, unsupported by falsework, was not strong enough to carry the load.

The centers footing on the 5th floor were spaced approximately 4 ft. apart and instead of the load being distributed by planks across the whole floor, the posts rested on small blocks, thus concentrating the whole load on one rib. The following computations are made on the assumption that the load was carried on one, two and three ribs, respectively.

The floor was designed for a live-load of 95 lb. per sq. ft. so that the resisting moment of a rib (assuming that rib had been correctly designed for the load) is as follows (see Fig. 1 for sizes):

RESISTING MOMENT

Live load = 95 lb. per sq.ft.
Dead load = 70 lb. per sq.ft.
Total load per lin.ft. of rib = $165 \times 1.33 = 220$ lb.

$$M_R = \frac{WL^2}{12} = \frac{220 \times 20^2 \times 12}{12} = 88{,}000 \text{ in.-lb.}$$

BENDING MOMENT

Weight of floor per sq.ft. = 70.
Weight of centering per sq.ft. per floor = 4.
No. of floors carried to the 5th floor = 2.
No. of centers carried to 5th floor = 3.
Then the load carried down each centering post
$2 \times 70 + 3 \times 4 = 152$ lb. per sq.ft.
Each post carried 4×4 ft. = 16 sq.ft.
$\therefore L = 16 \times 152 = 2432$ lb.

Each floor panel length of 20-ft. span carries four posts spaced 4 ft. c. to c. Considering one rib to carry a line of posts its bending moment is as follows:

MBL (moment from load of centers)	= 29,184 ft.-lb.
MBD (moment from weight of rib)	= 4,665 ft.-lb.
	33,849 ft.-lb.

The same figures for two and three ribs.

	2 ribs	3 ribs
MBL	29,184	29,184
MBD	9,230	13,995
	38,414	43,179 ft.-lb.

The comparisor between bending and resisting moments is in in.-lb. then

	1 rib	2 ribs	3 ribs
Bending moment.....	406,000	461,000	518,000
Resisting moment.....	88,000	176,000	264,000
MB ÷ MR =.....	4.62	2.62	1.96

As the ribs were designed for a compressive stress in the concrete of 750 lb. per sq.in., the foregoing ratios would show a compressive stress at the time of failure in excess of the strength of the concrete which had not yet attained full strength.

This computation does not take account of the moving weights of the men, wheelbarrows, freshly dumped concrete and other excess loadings incident to construction. It is also obviously approximate in determining the stresses. It does indicate, however, the excessive loading that the 5th floor had to carry.

American Society of Agricultural Engineers

The seventh annual meeting was held at the Great Northern Hotel, Chicago, on Dec. 29 to 31. In the opening address of the president, Prof. L. W. Chase (University of Nebraska), the growth of the application of engineering to farm and agricultural work was pointed out, and it was shown that there is a wide field for the extension of this movement.

A paper on "Farm Sanitation" was read by Paul Hansen, Engineer of the Illinois State Water Survey. This had reference specially to water-supply, the protection of wells, the disposal of sewage, and the possibilities of introducing modern conveniences in farm houses. Papers on "Permanent Farm Buildings" and "Concrete in Drainage Work" were presented by E. S. Fowler and C. W. Boynton, of the Universal Portland Cement Co. The latter referred to the manufacture of drain tile and to a system of draining swamp lands by vertical drains carried through the impervious substratum to a permeable stratum underlying the former.

In the discussion on buildings, plans for a large concrete cow barn were presented by John Bowditch, Jr., of the Trussed Concrete Steel Co. The large storage space in the upper portion had a concrete floor but the roof was of tile on timber trusses and framing. The question as to the use of steel or concrete construction for this upper work was discussed, but Mr. Bowditch held that in view of the heat and the expansion of the air, a fire in this space would destroy any kind of roof. The tile would prevent the roof catching fire from without, but hay-barn fires usually result from dropped matches, overturned lamps, etc.

A paper on the "Standardizing of Wagon Construction" was read by E. Parsonage, of the John Deere Wagon Co., who advocated this move in the interests of the builders and users. In the discussion, the general idea was approved by E. W. McCullough, of the National Implement and Vehicle Association, but he did not approve of leaving this to the manufacturer entirely. For instance, the width of wagon affected general traffic and the width of tire affected the wear and maintenance of roads. He thought the matter should be dealt with jointly by representatives of the wagon, automobile, farming and good-roads interests.

One group of papers related to the use of machinery in farm work, and C. J. Rohrer (General Electric Co.) in a paper on "Small Motor Applications for Farm Work" showed some half-dozen applications in dairy work (pumping, churning, milking, separating, refrigerating, etc.) and 30 applications in barn and field work. The motors ranged from ¼ hp. to 40 hp., the latter for large threshers. Portable electric plants and transmission lines on large farms were noted also. In the discussion, one speaker exhibited a map of the system of a large electric company in northern Illinois which has a series of power plants and a connecting system of transmission lines extending through several counties and affording opportunity for power development for farms and dairies.

A paper by P. S. Rose, of the *American Thresherman*, discussed the tractor or traction-engine tests at Winnipeg, in relation to proposed official tests in this country. Prof. Chase presented the report of a committee appointed by the Society a few months ago to take up the matter of such tests with the managers of county fairs, exhibitions, implement shows, etc. The committee will prepare rules and regulations for the tests and supervise the testing and judging.

Officers were elected as follows: President, W. F. MacGregor, Racine, Wis.; Vice-Presidents, J. L. Mowry, St. Paul, Minn., and J. A. King, Otranto, Iowa; Secretary and Treasurer, F. M. White, Madison, Wis.

The Reinforced-Concrete Conduit Break at Montreal

As reported in our last issue, Montreal's 400,000 inhabitants were thrown into a serious condition on Dec. 25, 1913, by the total failure of the water-supply through a bad break of the supply conduit. At the time our report went to press it was expected that repairs would be completed late on Tuesday, Dec. 30. This hope was disappointed, by three days, and the supply was not restored until late Friday evening, Jan. 2, 1914.

The view, Fig. 1, above, shows the break as it [illegible] veloped. The side wall of the conduit, facing the ca[illegible] excavation (in the foreground) and less than 10 ft. fr[illegible] the slope, broke out on a length of 60 ft. The two low[illegible] views, Figs. 2 and 3, show successive stages of the [illegible] pair. The ruptured section was first broken out e[illegible] tirely; Fig. 2 shows this work nearly completed. The[illegible] 120 lin.ft. of 7-ft. steel riveted pipe were set in, bridging the gap and entering the conduit about 30 ft. on either side. The pipe across the gap was blocked up from the ground below, and was stiffened by a surrounding cradle

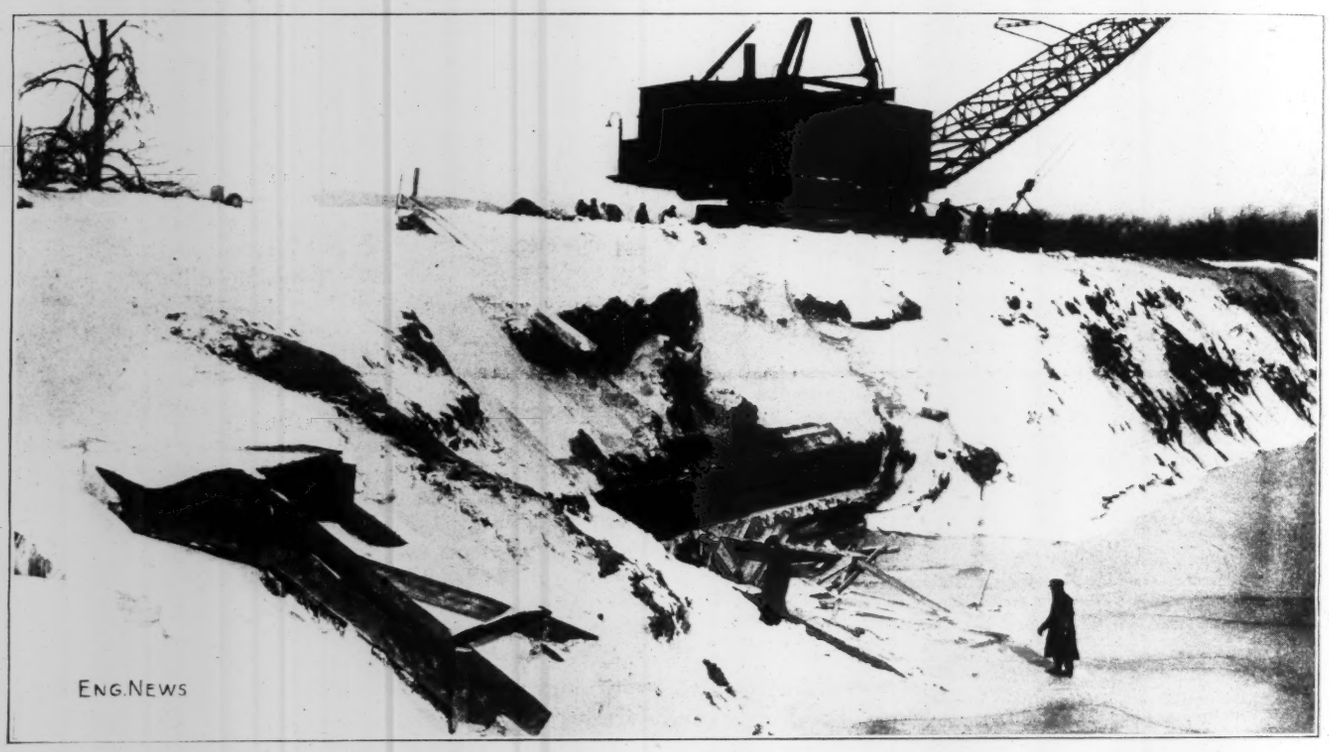


FIG. 1. BREAK IN THE MONTREAL WATER CONDUIT, PHOTOGRAPHED SOON AFTER IT OCCURRED

FIG. 2. BROKEN CONDUIT SECTION SMASHED DOWN AND CLEARED AWAY FOR REPAIR

FIG. 3. STEEL-PIPE THIMBLE 7x120 FT., NEARLY COMPLETED

THE CHRISTMAS-DAY BREAK IN MONTREAL'S WATER CONDUIT, A 9x7½-FT. REINFORCED-CONCRETE HORSESHOE TUBE

of timber. The ends were to be sealed into the conduit with cement mortar. The width of the annular seal space was 4 in. to 12 in., and its length 30 ft. The inner end of the space was bulkheaded with brick laid in bituminous cement, and then the space partly filled with lagged cement and "cement-gun" mortar.

Water was let into the conduit by opening the gates at the intake, Wednesday, Dec. 31, as soon as the seal was all in. Leaks at the repaired break developed almost immediately, partly in the seal and partly at the joints of the lengths of pipe. It was necessary to close the gates, empty the conduit, tighten the joints, and repair the seal. The pipe was jointed by bolts through angle-iron flanges *inside*; therefore, the water had to be drawn off to tighten the bolts. This was slow work because of inadequate facilities for draining the conduit. A manhole having been cut in the top of the steel pipe to enter it, the men working at the joints set to work on a raft, floating on the water inside.

After the gates at the intake were again opened, Friday evening, some further calking of the joints was done. The seal also having been improved, the repaired conduit proved able to continue in service, delivering the normal supply to the pumping station at the lower end of the conduit, though minor leaks were flowing several days later.

The failure of the city's only water-supply line was particularly serious in Montreal's case because the city has only a trifling amount of storage in its reservoirs, the total storage being about 37 million Imperial gallons (McTavish or low-service reservoir 35,000,000; high-service reservoir 1,600,000) against a daily consumption of about 50 million. Larger storage has been recommended at various times during the past *sixty years,* but the city officials never acted on these urgings.

Fortunately, about half the city is on a private water system. The Montreal Water & Power Co. supplies about 250,000 people, of which about 190,000 are within the present city limits and 60,000 live in adjacent towns not incorporated with the city. This system was not affected, and it not only continued the supply to its regular customers without curtailment but also pumped into the city's mains an amount greater than 50% of the company's regular pumpage.

*

Henry M. Waite, City Manager of Dayton, Ohio; the City-Manager Form of Municipal Government

The commissioners of Dayton, Ohio, the first large city to experiment with the City-Manager plan of municipal government, have selected for the office of City Manager an engineer, Henry M. Waite, of Cincinnati, as noted in our personal columns of Dec. 18, 1913. As wide publicity has already been given to the fact that Mr. Waite is a civil engineer by training and experience, it seems that his is a unique opportunity to demonstrate that this training, and the training of engineers generally, peculiarly fits the members of the profession to administer the business of a large city, so much of which consists of the design, construction and operation of various public works and utilities. The conditions in Dayton, too—its complete rehabilitation after the disastrous floods of last spring—are such as to require an extraordinary amount of zeal and ability on the part of the chief executive, and seem to offer every opportunity for a notable administration.

Mr. Waite comes to his office as City Manager of Dayton from the neighboring city of Cincinnati, where for the past year he has been Chief Engineer of the Department of Public Works. During this short period he completely reorganized the city engineering department, which, under his general supervision, has carried out a comprehensive investigation for a new sewerage system, and studies for a rapid-transit system. The survey work for the sewerage system has been nearly completed and has been notable for its thoroughness and completeness. The rapid-transit system surveys, and estimates for a 15-mile loop around the city, part of which is to be subway, are now nearly completed. In all this work, Mr. Waite has shown the ability to grasp quickly a multiplicity of engineering problems, and within a short time he has organized an able staff of engineering assistants, whose appointments were based solely upon their fitness for their positions, and without regard to their political affiliations or even their citizenship in Cincinnati or in Ohio, which local politicians tried hard to have insisted upon.

(Courtesy of "Collier's Weekly," New York City.)

Mr. Waite is in his 45th year. He was born in Toledo, Ohio, May 15, 1869. He attended the Massachusetts Institute of Technology for four years, 1886-1890,

as a member of the class of 1890 in the course of civil engineering. Following his college course he entered the employ of the Cleveland, Cincinnati, Chicago & St. Louis Ry. as a transitman. The next year he was promoted to be Assistant Engineer of the Chicago division, and from 1892 to 1893 he was Engineer of Maintenance-of-way of the St. Louis division.

From April to August, 1893, Mr. Waite was Division Engineer of the Cincinnati division of the Cincinnati, New Orleans & Texas Pacific Ry.; subsequently he spent a year as Roadmaster of the Louisville Southern R.R. He returned to the service of the Cincinnati, New Orleans & Texas Pacific Ry. in 1894 as Superintendent of Bridges of the Cincinnati division, where he remained for 13 years, five in this position and as Roadmaster, and eight years as Division Superintendent, the last two years of which were spent in charge of the Chattanooga division at a time when a great deal of double-tracking work was done. After two years as Division Superintendent of the Seaboard Air Line Ry., in 1909, Mr. Waite was made Vice-President and Chief Engineer of the Clinchfield Coal Corporation at Dante, W. Va., which position he left early in 1912 to become Chief Engineer of the city engineering department of Cincinnati.

THE DAYTON CITY CHARTER—The charter under which Mr. Waite received his Dayton appointment provides for a city commission of five members elected for four years, with partial renewal of the commission every two years. The commissioners may be removed by recall. The Mayor is the commissioner who receives the largest number of votes at the election of the commission. His salary is $1800 per annum and the salary of the other commissioners $1200.

The commissioners constitute a legislative body which has no executive authority. The Mayor is the presiding officer of the commission; he is recognized as the official head of the city by the courts for the purpose of serving civil processes, and by the Governor of Ohio for the purposes of military law, and for all ceremonial purposes. If the office becomes vacant, the other commissioners may elect one of their number Mayor.

The important clauses in the city charter relating to the office of City Manager read as follows:

Sec. 47. The commission shall appoint a City Manager who shall be the administrative head of the municipal government and shall be responsible for the efficient administration of all departments. He shall be appointed without regard to his political beliefs and may or may not be a resident of the city of Dayton when appointed. He shall hold office at the will of the commission and shall be subject to recall as herein provided.

Sec. 48. Powers and duties of the City Manager. The powers and duties of the City Manager shall be:

(a) To see that the laws and ordinances are enforced.

(b) To appoint and, except as herein provided, remove all directors of departments and all subordinate officers and employees in the departments in both the classified and unclassified service; all appointments to be upon merit and fitness alone, and in the classified service all appointments and removals to be subject to the civil service provisions of this charter;

(c) To exercise control over all departments and divisions created herein or that may be hereafter created by the commission;

(d) To attend all meetings of the commission, with a right to take part in the discussion but having no vote;

(e) To recommend to the commission for adoption such measures as he may deem necessary or expedient;

(f) To keep the commission fully advised as to the financial condition and needs of the city; and

(g) To perform such other duties as may be prescribed by this charter or be required of him by ordinance or resolution of the commission.

Sec. 49. Salary. The City Manager shall receive such salary as shall be fixed by ordinance of the commission.*

Sec. 50. Investigations by City Manager. The City Manager may without notice cause the affairs of any department or the conduct of any officer or employee to be examined. Any person or persons appointed by the City Manager to examine the affairs of any department or the conduct of any officer or employee shall have the same power to compel the attendance of witnesses and the production of books and papers and other evidence, and to cause witnesses to be punished for contempt, as is conferred upon the commission by this charter.

The adoption of the City-Manager plan by Dayton was made possible by recent constitutional amendments and legislative enactments which give all Ohio cities a large measure of municipal home rule, including the very important privilege of framing their own charters through an elected board and adopting or rejecting such charters by popular vote—all without recourse to the State legislature. The Ohio statute under which Dayton or any other city may adopt the City-Manager plan reads as follows:

ARTICLE IV

Sec. 8. City Manager. The council shall appoint a City Manager who shall be the administrative head of the municipal government under the direction and supervision of the council and who shall hold office at the pleasure of the council.

Sec. 9. Duties City Manager. The duties of the City Manager shall be: (a) to see that the laws and ordinances are faithfully executed; (b) to attend all meetings of the council at which his attendance may be required by that body; (c) to recommend for adoption to the council such measures as he may deem necessary or expedient; (d) to appoint all officers and employees in the classified service of the municipality, subject to the provisions of this act,† and of the civil service law; (e) to prepare and submit to the council such reports as may be required by that body, or as he may deem advisable to submit; (f) to keep the council fully advised of the financial condition of the municipality and its future needs; (g) to prepare and submit to the council a tentative budget for the next fiscal year; (h) and to perform such other duties as the council may determine by ordinance or resolution.

Sec. 10. Salary of City Manager. The City Manager shall receive such salary as may be fixed by the council; and before entering upon the duties of this office he shall take the official oath required by this act and shall execute a bond in favor of the municipality for the faithful performance of his duties in such sum as may be fixed by the council.

For precedent the new City Manager of Dayton has only the small cities of Staunton, Va., which in 1909 created the office of General Manager, the city of Sumter, S. C., which on June 12, 1912, adopted the City-Manager plan and appointed an engineer, M. M. Worthington, to fill the position, and the town of Hickory, N. C., which has a population of only 3716. The cities of Springfield, Ohio, La Grande, Ore., and Phoenix, Ariz., have recently adopted the City-Manager plan, but have not yet begun operation under new charters.

Damage by Ocean Storms at Seabright, N. J., and Other Coast Resorts

The severe northeast storm of Christmas day and the day following caused great damage at the summer resorts along the coast of New Jersey and still greater damage was done by the even more severe storm of Jan. 3-4, in both cases, as the result of erosion of the beach by wave action during phenomenally high tides. The wind veloc-

*$12,500.

†The council appoints the auditor, clerk, treasurer and solicitor.

ity of the first storm reached 98 miles per hour, and in the second 96 miles per hour, according to the U. S. Weather Bureau station at Long Branch, N. J. In the latter storm, the high wind continued for a much longer time than in the storm of Dec. 25-26. The recorded wind movement for the 24 hours ending at noon on Jan. 4 was 1170 miles. The greatest damage was done at Seabright, N. J. There the high winds drove the seas with shattering force against the bulkheads, built along the shore. These bulkheads were weakened in many places by the first storm and utterly demolished in the second.

Seabright is divided, locally, into three sections, known as South Beach, Seabright and North Beach. The greatest damage occurred at Seabright proper where the large Octagon Hotel and the Annex to the Peninsula Hotel, were destroyed. On Saturday night (Jan. 3), it was seen that the south wing of the Octagon, which comprised the dining room, kitchen and storeroom, was in imminent danger of being washed away, so the furniture, in that wing was transferred to the main part of the hotel. The south wing was broken to pieces and washed away as expected, but on Jan. 4 the main part of the hotel followed. Attempts had been made to shore up this latter part; in fact, shorers were at work setting piles at the time of its destruction; but the head room under the building was insufficient to allow of adequate reinforcement. A pile penetration of only about 8 to 9 ft. was attainable. The hotel was only about 50 ft. back from the shore bulkhead and was built so close to the ground that when the bulkhead was broken and the earth between it and the hotel was washed away, the latter was speedily undermined and carried to sea where it was broken to pieces. The wreck of the Octagon is shown in the halftones.

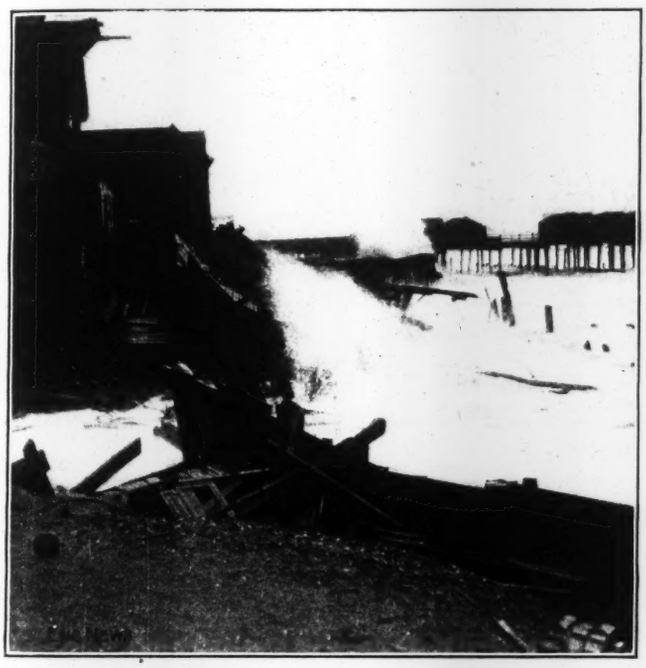


FIG. 1. OCEAN SIDE OF THE BIG OCTAGON HOTEL BEFORE THE FINAL COLLAPSE, SHOWING A PORTION OF THE WRECKED BULKHEAD

The same conditions existed in the case of the Peninsula Hotel Annex, situated on adjoining property. The Peninsula Hotel itself escaped because of its more distant location from the sea. Furthermore, only one end of the Peninsula overlooks the sea while the Octagon was constructed broadside to the ocean. The Octagon Annex still stands as does a small section of the adjacent hotel proper; the rest of the building was demolished. Both the Octagon and the Peninsula were insufficiently protected against such a catastrophe because of the weak bulkhead and brick building foundations.

Many of the summer cottages, which lie along the coast, north and south of the two large hotels, were more or less damaged. Twenty of the latter have been placed in charge of J. A. Howland, bulkhead contractor, of Seabright. Mr. Howland believes that these will be saved by strong shoring.

Just south of the Octagon Hotel is the fishing village, consisting formerly of a hundred or so small cottages and shacks. More than 20 of these were destroyed. Some, which were in danger, were saved by being jacked up and moved back a hundred feet or more.

The usual type of shore bulkhead at Seabright is constructed in the following manner. A row of piles, 5 to 6 ft. apart, 30 ft. in length, with a butt diameter of 16 to 20 in., is sunk by jetting to a penetration of about

FIG. 2. LAND SIDE OF THE OCTAGON HOTEL AFTER ITS COLLAPSE ON JAN. 4.

20 ft. Three lines of 6x12-in. stringers are then bolted to the piles (one at the top, one at about the middle, and the third at the foot). A back 6x12-in. stringer is bolted to the piles, opposite the top line of stringers. Yellow pine, tongued-and-grooved sheet piling, 20 to 24 ft. long, with a penetration of 10 to 14 ft., is then driven and bolted to the stringers. Sand is filled in, on the landward side, to the top of the bulkhead.

This type of bulkhead construction prevails from the town of Galilee, northward a distance of about 1½ miles. In the years since this bulkhead was built, the beach has been washed away to such an extent that at low tide the water is said to have averaged 6 ft. deep at the bulkhead and at high tide 10 to 10½ ft.—about the height of the bulkhead.

At South Beach, part of the bulkhead was of the rock-fill type; i.e., rocks were packed between two rows of piles. This was better than the prevailing method, but was, nevertheless, inadequate as the water undermined it and ripped it away in a number of places.

A bulkhead worth noting because of its stability, was that in front of the property of John Harson Rhodes at Lowmoor. Piles were driven in the same manner as previously described; but from each, a pile or strut was driven diagonally at an angle of about 60° and bolted to the perpendicular pile. Horizontal sheathing of 6x12-in. tongued-and-grooved yellow pine was then bolted to the vertical piles and extended about 8 ft. below the boardwalk level, which was about 2 or 3 ft. below the tops of the piles. The latter projected above the boardwalk and, by means of cross-sheathing, formed a bulwark, through which scuppers were cut. Below the sheathing, a line of 6x12-in. stringers were bolted to the piles; and beneath this line, two thicknesses of sheet piling were sunk to a penetration of about 10 ft. According to J. A. Howland, the builder, this bulkhead was not damaged.

After the storm of Dec. 25-26, a temporary bulkhead, of short piling, 4-in. stringers and 2-in. sheet piling, was constructed in front of the Peninsula and Octagon hotels; but it was too weak to stand the buffeting of the sea.

The damage at Seabright, due to the storm of Dec. 25-26, is estimated at about $100,000, and that resulting from the storm of Jan. 3-4, at about $500,000. Two conclusions stand out prominently: (1) That the strength of a bulkhead should be proportional to the value of the property it is intended to protect; (2) that the foundations of an exposed seaside cottage should not be built of brick but of concrete or, better, tongued-and-grooved concrete sheet piling of sufficient penetration. If concrete piles were placed at the corners of the foundations and the distances between bricked, a much stronger construction than the present all-brick type, would result.

Damage at Other Coast Resorts

Few of the coast resorts of New Jersey or Long Island escaped serious damage. It is reported that the highest tide in 15 years was recorded at Longport and Margate City, N. J.; the streets of both towns were flooded, sections of boardwalks were ripped up and several cottages were destroyed in Longport. The heavy sea made large gaps in the concrete bulkhead at Ventnor, Longport and Margate City. A 300-ft. section of the Million Dollar Pier at Atlantic City, N. J., collapsed.

At Cape May, N. J., a 1500-x600-ft. section of the beach-front boulevard, starting one block south of the Hotel Cape May, is reported to have been cut away by the actions of the waves.

At Coney Island the most serious damage was done by the storm at Sea Gate. There, at a point opposite the lighthouse at Norton's Point, more than two acres of land are reported to have been submerged. The summer home of Phillip Torchio, Electrical Engineer of the New York Edison Co., situated about 125 ft. from the Sea Gate sea wall, was undermined by the waves and submerged. In an effort to save the cottage, six carloads of rock and 2000 bags of sand are said to have been piled on the lawn, but this ballast was undermined and washed away.

The Arverne Pier Theater, on the boardwalk at Arverne, L. I., is reported to have been lifted from its piling and broken up. The structure was 100x200 ft. in plan and seated about 1200 persons. Half a mile of the boardwalk was torn away.

At Rehoboth, Del., the storm is said to have devastated the entire beach front. More than 200 ft. of boardwalk above the Hotel Henlopen was completely washed away and the buildings along the beach were undermined. At Dewey Beach, two miles below Rehoboth, a strip of beach 1000 ft. wide was washed away and united the ocean with Rehoboth Bay.

NEWS NOTES

Electrical Energy for the suburban lines of the Pennsylvania R.R. out of Philadelphia has been contracted for with the Philadelphia Electric Co. The electrification plans for these lines have been noted in "Engineering News," Apr. 3, Oct. 9 and Dec. 25, 1913, pp. 656, 733, 1331.

A Railroad Bridge Washout occurred on Dec. 5, at the new bridge of the St. Louis, San Francisco & Texas Ry., connecting Van Buren and Sebastian counties, Ark., due to the flooding of the Arkansas River. A section of wooden trestlework became weakened from scour, according to a press dispatch. Four cars of coal which acted as ballast fell into the river.

The Elimination of Grade Crossings in New England is at a standstill as the result of the financial condition of the New England railways. The Boston & Maine R.R., which has hitherto coöperated cheerfully with the States and the towns affected in the work of grade-crossing abolition, this year announces its opposition to all such improvements on the ground that it has not the money to spend, and in the present state of the financial market it is impossible to obtain the money.

A Tenement House Fire gutted the five-story tenement at 96 Monroe St., New York City, shortly after 4 a.m., on Dec. 31. Eight persons, five men and three women, were burned to death and a number were injured. There were 100 persons in the building at the time of the fire, and the press reports state that the second floor fire escape was so congested with people that the latter were apparently unable to drop the fire-escape ladder from that floor to the street. This was accomplished by the police.

The Last Spike in the Sudbury-Port Arthur section, 617 miles long, of the Canadian Northern Ry., was driven Jan. 1, by the President, Sir William MacKenzie, at a point 254 miles east of Port Arthur and 616 miles northwest of Toronto. This section is a part of the Montreal-Port Arthur line (1023 miles) in the Canadian Northern transcontinental route, described in "Engineering News," June 27, 1912, and July 10, 1913. This section links together the company's eastern and western lines. A gap of some 150 miles, in the Rocky Mountains, and a stretch of 160 miles between Ottawa and Capreol, both of which will be completed early in 1914, alone remain from Quebec to Vancouver. The eastern gap in the main line, however, is bridged by the branch lines Ottawa-Toronto and Toronto-Sudbury.

PERSONALS

Mr. John R. Seibert has resigned as City Engineer of Pekin, Ill.

Mr. George Wales has been appointed City Engineer of Central City, Ky.

Mr. E. A. White, of Springfield, Ill., has been appointed County Highway Superintendent of Sangamon County, Ill., at a salary of $2500 per annum.

Mr. S. S. Arentz, Chief Engineer of Construction of the Salt Lake & Utah R.R., at Salt Lake City, Utah, has resigned to engage in private practice.

Mr. F. R. Bartles, Trainmaster of the Northern Pacific Ry., at Pasco, Wash., has been promoted to be Superintendent of the Fargo division, at Dilworth, Minn.

Mr. W. H. Andrews, Superintendent of the Georgetown & Western R.R., has been promoted to be General Manager, with headquarters at Georgetown, S. C.

Mr. C. L. Hinkle, Superintendent of the Toledo, St. Louis & Western Ry., has been promoted to be General Superintendent with headquarters at Frankfort, Ind.

Mr. J. Waldo Smith, M. Am. Soc. C. E., Chief Engineer of the Board of Water Supply, New York City, was married, Dec. 30, to Miss Anne Louise Morse, of Brooklyn, N. Y.

Mr. Walter A. Shaw, engineer of the Illinois Rivers and Lakes Commission, has been appointed a member of the new Public Utilities Commission of Illinois by Governor Dunne.

Mr. Angus Smith, M. Can. Soc. C. E., who has served as City Engineer of Stratford, Ont., Victoria, B. C., and Regina, Sask., has now been made City Engineer of Prince Albert, Sask.

Mr. W. Earl Weller, Assoc. M. Am. Soc. C. E., recently Assistant Engineer, Bureau of Power Equipment, New York State Barge Canal, has been appointed Deputy City Engineer of Schenectady, N. Y.

Mr. William E. Chapman, for the past three years Assistant City Engineer, of Dillon, Mont., has been appointed City Engineer. He was formerly with the Gilmore & Pittsburgh R.R., at Armstead, Mont.

Mr. Carroll A. Moses, of the city engineering department of New Orleans, La., has been appointed Assistant Engineer of the Public Belt R.R. municipal railway, of which the City Engineer is Chief Engineer.

Mr. W. F. Steffens, Assoc. M. Am. Soc. C. E., Acting Chief Engineer of the Chesapeake & Ohio Ry., has resigned. Mr. Steffens was formerly Engineer of Structures of the Boston & Albany R.R., at Boston, Mass.

Mr. L. D. Smoot, for a number of years with the engineering department of the District of Columbia, and recently City Engineer of Jacksonville, Fla., has been elected Commissioner of Public Works of Jacksonville.

Mr. Henry W. Hayes, M. Am. Soc. C. E., recently Engineer of Grade Crossings in the Department of the Attorney General of Massachusetts, has been appointed Engineer of the Massachusetts Public Service Commission.

Mr. George R. Metlen, recently City Engineer of Dillon, Mont., and for many years a civil and mining engineer with offices at Dillon, has been appointed Secretary of the Montana Highway Commission, with office at Helena.

Mr. W. C. Hurst has resigned as General Superintendent of the Eastern district of the Pere Marquette R.R., at Saginaw, Mich., to become Vice-President and General Manager of the Chicago, Peoria & St. Louis R.R., at Springfield, Ill.

Mr. E. F. Ruggles has resigned as First Assistant Engineer of the Maryland State Roads Commission. The engineering department of the commission has been reorganized and the position of First Assistant Engineer is abolished.

Mr. Louis L. Tribus, M. Am. Soc. C. E., Consulting Engineer and Acting Commissioner of Public Works, Borough of Richmond, New York City, has resigned. Mr. Tribus is a member of the firm of Tribus & Massa, Civil and Hydraulic Engineers, New York City.

Mr. H. C. Williams, Assistant Chief Engineer of Construction of the Louisville & Nashville R.R., Louisville, Ky., has been promoted to be Chief Engineer of Construction, succeeding Mr. John H. Peyton, M. Am. Soc. C. E., resigned, as noted in our personal columns of Dec. 25.

Mr. Albert J. Romer has resigned his position with the escalator engineering department of the Otis Elevator Co., New York City, in order to enter into the manufacture of cyclecars, a new type of a small automobile. Mr. Romer was formerly Mechanical Engineer with the United States Motor Co

Messrs. Frank B. Fluck and Elmer O. Long announce the formation of the partnership of Fluck & Long, Civil and Mining Engineers, Somerset, Penn. Mr. Fluck has had 20 years' practice in coal mining in Pennsylvania, and Mr. Long was formerly with the engineering department of the Consolidated Coal Co., at Somerset.

Mr. William H. Edwards, recently Commissioner of Street Cleaning, New York City, has been appointed General Manager for Mr. Joseph Marrone, who has a contract for the refuse disposal of the city of Newark, N. J. Mr. Edwards is reported to have signed a contract with Mr. Marrone for two years at $10,000 per annum.

Mr. J. E. Griffith, M. Can. Soc. C. E., has been appointed Deputy Minister of Public Works, of British Columbia, Victoria, B. C. Mr. Griffith has had over 30 years' engineering experience on Canadian and South American railways. He has been Engineer of the Department of Public Works of British Columbia for the past three years.

Mr. William B. Landreth, M. Am. Soc. C. E., has been appointed City Engineer of Schenectady, N. Y. Mr. Landreth was connected with the New York State engineering department for many years, and for four years was Deputy State Engineer. For the past few years he has been in private practice as Consulting Engineer at Schenectady.

Mr. Evan P. Bone, Junior Engineer, United States War Department, of Cincinnati, Ohio, has been appointed Engineer of Construction of Ohio River Dam No. 39, near Vevay, about 60 miles below Cincinnati. This dam is one on which contractors refused to submit bids. Mr. Bone is the son of a Cincinnati contractor and has had considerable experience on other Ohio River dams.

Mr. Charles E. Ashburner, former General Manager of Staunton, Va., has been selected by the commissioners of Springfield, Ohio, to be City Manager, under the new Ohio statute, a section of which is quoted elsewhere in this issue. The Staunton plan of city government was described at length in our issue of July 8, 1909, p. 32, by R. D. Haislip, Editor of the Staunton "Dispatch."

Mr. F. J. H. Kracke, former Naval Officer of the Port of New York, has been appointed Commissioner of Bridges of New York City at a salary of $7500 per annum. The Commissioner of Bridges has jurisdiction over the construction, repair, management and maintenance of all bridges in Greater New York. With the exceptions of Messrs. Gustav Lindenthal and Kingsley L. Martin, M's. Am. Soc. C. E., this office has seldom or never been filled by an engineer.

Mr. Joseph Kemper, a former Deputy City Engineer of Utica, N. Y., has been appointed City Engineer. Mr. Kemper graduated from the University of Pennsylvania and for a number of years was with the engineering staff of the Bureau of Surveys, Philadelphia, Penn. In 1898-'99 he was Deputy City Engineer and Acting City Engineer of Utica. Since 1900, with the exception of two years, 1910-'12, as Deputy City Enginer, he has been in private in Utica.

Mr. Horace Loomis, M. Am. Soc. C. E., Consulting Engineer for Sewers, Office of the President of the Borough of Manhattan, New York City, was retired Dec. 31, at half pay, after 37 years of continuous service with the engineering staff of the City of New York. Mr. Loomis is 74 years old and graduated from Rensselaer Polytechnic Institute in 1865. He has been a member of the American Society of Civil Engineers since 1879, and is a charter member of the Engineers' Club, where a complimentary dinner is to be given him on Jan. 16.

Mr. William J. Norton, M. Am. Inst. E. E., has resigned his position with the Commonwealth Edison Co., Chicago, Ill., to engage in private practice as a member of the firm of Norton & Bird, Consulting Engineers, Chicago. Mr. Norton was born in Baltimore, Md., and was educated at the Baltimore City College and Cornell University, where he graduated in mechanical engineering in 1902. From 1907 to 1911 Mr. Norton was First Assistant Secretary of Public Service Commission of New York State, First District.

Mr. Clarence Hall has resigned his office as expert in charge of the explosives section of the United States Bureau of Mines in order to establish an industrial laboratory in Pittsburgh, Penn. Mr. Hall will make a specialty of analyses and tests of explosives, and will undertake investigations both in the office and in the field, to determine the suitability of the explosives with respect to their safety and adaptability to any particular work. A part of the work of the new laboratory will be to investigate new processes and improvements in methods of manufacture of explosives.

Mr. Lewis Nixon, a naval architect and shipbuilder, has been appointed Consulting Engineer and Acting Commissioner of Public Works of the Borough of Richmond, New York City, at a salary of $8000 per annum, succeeding Mr L. L. Tribus, M. Am. Soc. C. E., resigned, as noted elsewhere

Mr. Nixon is a graduate of the United States Naval Academy at Annapolis, Md., and has had considerable experience as a Naval Constructor. In recent years he has been a prominent politician in New York City, and in 1902 succeeded Mr. Richard Croker as the head of Tammany Hall. He has served on many National and State Commissions. He is a member of the council of the Society of Naval Architects and Marine Engineers.

Mr. James E. Barlow, Assoc. M. Am. Soc. C. E., Principal Assistant City Engineer of Cincinnati, Ohio, has resigned to follow his former chief, Mr. Henry M. Waite, to Dayton, Ohio, where he becomes Service Director under the city-manager plan of municipal government. Mr. Barlow graduated from the Massachusetts Institute of Technology in 1905. For a few years he was Assistant Engineer in the designing department of the Board of Water Supply, City of New York. Later he became connected with the Bureau of Municipal Research, and previous to his position with the city engineering department of Cincinnati he was employed there on work for the Bureau. His salary at Dayton will be $4000 per annum.

Mr. Paul M. Bird, M. Am. Soc. M. E., has resigned his position with the Commonwealth Edison Co., Chicago, Ill., to become associated with Mr. William J. Norton, M. Am. Inst. E. E., under the firm name of Norton & Bird, as noted elsewhere in these columns. Mr. Bird is a mechanical engineering graduate of Cornell University. Before going to Chicago he had had several years' experience with the Newport News Shipbuilding Co., Newport News, Va., and as an Instructor at Cornell University. At Chicago he was for four years Steam Engineer of the Illinois Steel Co., at the South Chicago works, and for four years Chief Smoke Inspector of the city. He is Chairman of the Chicago branch of the American Society of Mechanical Engineers.

Mr. John T. Fetherston, M. Am. Soc. C. E., recently Engineer-in-Chief of the Bureau of Street Cleaning, Borough of Richmond, New York City, has been appointed Commissioner of Street Cleaning of New York City at a salary of $7500 per annum, succeeding Mr. W. H. Edwards. Mr. Fetherston is a native of Staten Island, N. Y., and a graduate in civil engineering of New York University, class of 1897. Previous to his college course he had had considerable experience as an axman, leveler and draftsman in the road department of New Brighton, Staten Island. From January, 1898, when Staten Island became a part of New York City, to the present time, Mr. Fetherston has been employed on the public works of this borough (the Borough of Richmond). Since May, 1904, he has been connected with the Bureau of Street Cleaning of the Borough as Assistant Engineer, Superintendent and Chief Engineer. In accepting Mr. Edwards' resignation Mayor Mitchell wrote:

> I have determined to appoint as your successor Mr. John T. Fetherston for the reason that he has become throughout the country the acknowledged leading expert on problems of street cleaning. That I have determined to select him is not to be interpreted as any reflection upon your administration, but is due to the conviction that the department requires the direction of a technical expert and that administratively it is wise to throw upon him the entire responsibility for the conduct of this work.

The Commissioner of Street Cleaning has charge of the street cleaning and removal of garbage and refuse in all the Boroughs of Greater New York except Richmond and Queens, which have separate bureaus under the Borough Presidents.

OBITUARY

George Herrick Billings, President and Director of the Compressed Steel Shafting Co., Boston, Mass., died at his home in that city Jan. 3. He was born in Taunton, Mass., in 1845. He was the inventor of several machines for the drawing of steel bars.

Christer P. Sanberg, M. Inst. C. E., designer of the Sanberg rail section, died in London, England, Dec. 4, aged 81 years. He was born in Sweden but for more than half a century had made England his home. He had an international practice as a railway consulting engineer.

Murray Forbes, Assoc. M. Am. Soc. C. E., Manager and Treasurer of the Westmoreland Water Co., died at his home in Greenburg, Penn., Dec. 28, from pneumonia. He was a native of Philadelphia and a graduate in mechanical engineering of the University of Pennsylvania. For a time he was employed by the Pennsylvania R.R., but since 1886, when he settled in Greenburg, he had been chiefly employed as an engineer and promoter of water-works companies. He was 50 years old and is survived by a widow and five children.

ENGINEERING SOCIETIES

COMING MEETINGS

MINING AND METALLURGICAL SOCIETY OF AMERICA.
Jan. 13. Annual meeting at New York City. Secy., W. R. Ingalls, 505 Pearl St., New York.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Jan. 16. Annual convention in New York. Secy., J. R. Wemlinger, 13 Park Row, New York City.

AMERICAN WOOD PRESERVERS' ASSOCIATION.
Jan. 20-22. Tenth annual convention at New Orleans, La. Secy., F. J. Angier, Timber Preservation Co., Baltimore, Md.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 21 Annual meeting in New York. Secy., Chas. W. Hunt, 220 W. 57th St., New York City.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 21-23. Annual meeting in New York. Secy., E. A. Scott, 29 W. 39th St., New York City.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 27-29. Annual meeting in Montreal, Que. Secy., Prof. C. H. McLeod, 176 Mansfield St., Montreal, Que.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 28-30. Annual meeting at Peoria, Ill. Secy., E. E. R. Tratman, 1144 Monadnock Block, Chicago, Ill.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Jan. 29-31. Midyear meeting in New York. Secy., E. B. Burritt, 29 W. 39th St., New York City.

NATIONAL LIME MANUFACTURERS' ASSOCIATION.
Feb. 4-5. Annual meeting at New York. Secy., Fred K. Irvine, Chicago, Ill.

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.
Feb. 12-14. Meeting at Chicago, Ill. Secy., J. P. Beck, 72 W. Adams St., Chicago, Ill.

AMERICAN CONCRETE INSTITUTE
Feb. 16-20. Annual meeting in Chicago, Ill. Secy., E. E. Krauss, Harrison Building, Philadelphia.

Kansas Engineering Society—The annual convention will be held in Lawrence, Kan., Jan. 20-21. The Secretary is T. J. Stricklen, Topeka, Kan.

The Cornell Society of Civil Engineers will hold its annual meeting at a dinner in New York City, Jan. 23, 1914. This is the week of the annual meeting of the American Society of Civil Engineers, and it is expected that a number of Cornell engineers attending the meeting of that Society will be able to go to the dinner of the Cornell Society. Information in regard to the dinner may be obtained from W. F. Edge, Cooper Union, New York City.

Indiana Engineering Society—The annual convention will be held at the Hotel Severin, Indianapolis, Jan. 22-24. The Secretary is Charles Brossmann, 1616 Merchants Bank Building, Indianapolis.

Michigan Engineering Association—The annual meeting will be held at East Lansing (Michigan Agricultural College), Jan. 13-15. The Secretary is Prof. Arthur J. Decker, Ann Arbor, Mich.

American Society of Civil Engineers—The 61st annual meeting of the Society will open at 10 a.m., on Jan. 21, at the Society House, in New York City, when the business meeting will be held. Lunch will be served there at 1 p.m., and at 2:30 a trip is planned for the inspection of the construction of the new subway on Broadway, by courtesy of the Public Service Commission for the First District and by the contractors for the sections inspected. A reception will be held in the evening at the Hotel Astor.

Jan. 22 will be devoted to a trip by special train to the Martins Creek and Tunkhannock Viaducts now under construction by the Delaware, Lackawanna & Western R.R., on the new change of line between Clark Summit and Hallstead, Penn. The train will leave Hoboken at 8:15 a.m., returning at about 6 p.m.; lunch will be served on board. There will be an informal smoker at 8:30 p.m., at the Society House. The committee of arrangements comprises Robert Ridgway, Henry W. Hodge and Charles Warren Hunt.

Three meetings will be held on Jan. 23 and 24, wherein "Road Construction and Maintenance" will be discussed. On Jan. 23, at 10 a.m., the subject for discussion will be "Engineering Organizations for Highway Work," divided as follows: "State Highway Engineering Organizations," by Samuel D. Foster; and "Municipal Highway Engineering Organizations," by Wm. H. Connell. At 2 p.m., the subject will be "Factors Limiting the Selection of Materials and of Methods in Highway Construction." The discussion will be opened by Paul E. Green. On Jan. 24, at 10 a.m., the discussion of "Equipment and Methods for Maintaining Bituminous Surfaces and Bituminous Pavements," will be opened by W. H. Farrington.